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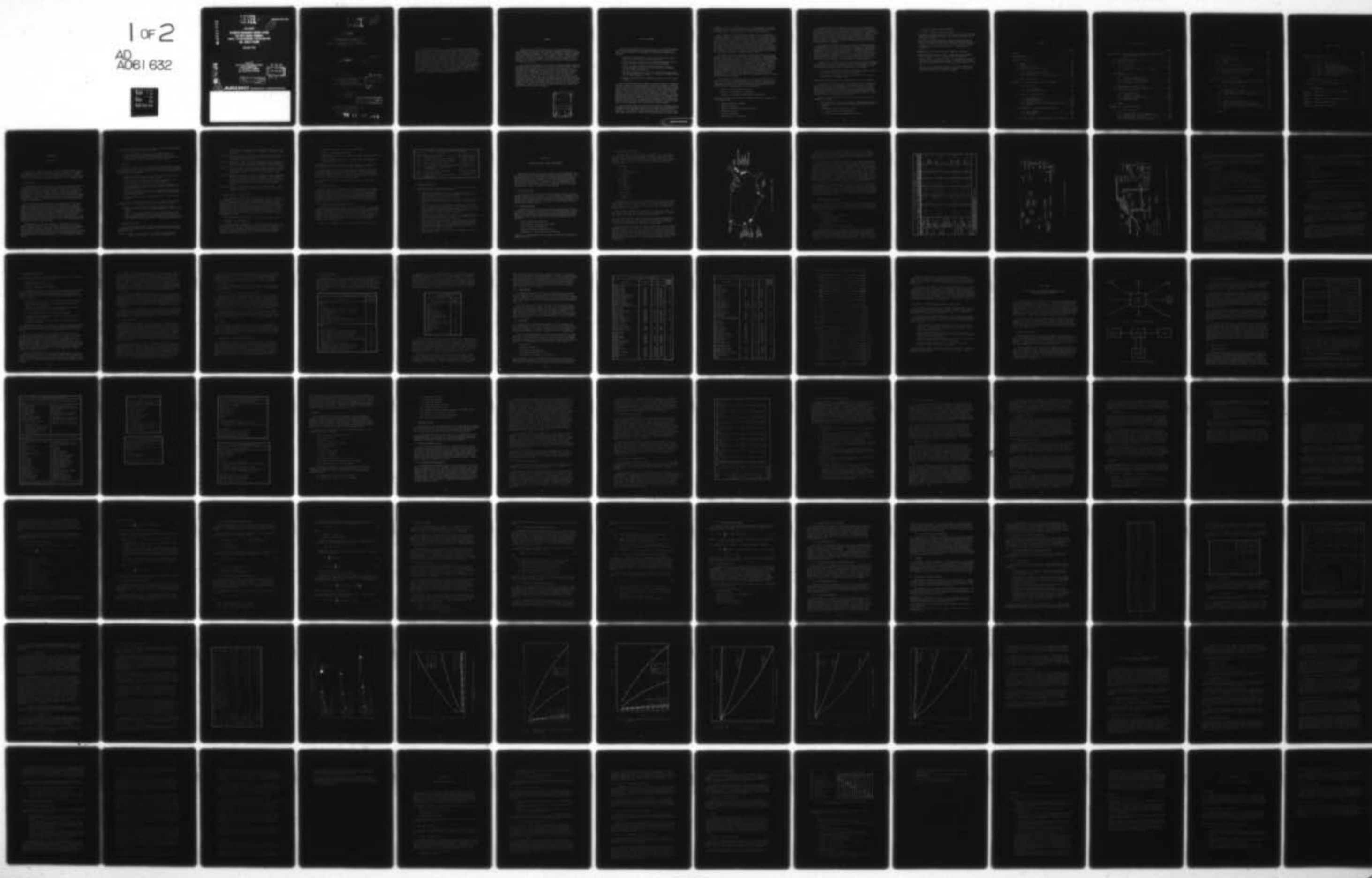

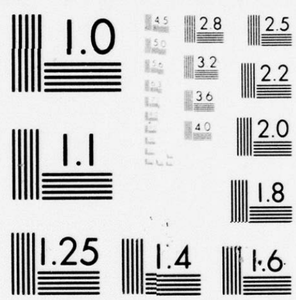

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FINAL REPORT

AUTOMATED MANAGEMENT CONTROL SYSTEM FOR PUBLIC MARINE TERMINALS PHASE I: SYSTEM DEFINITION, SYSTEM ANALYSIS, AND CONCEPT DESIGN

November 1978

Prepared for
OFFICE OF PORT AND INTERMODAL SYSTEMS
MARITIME ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
under Contract DO-A01-78-00-3006

ARINC RESEARCH CORPORATION

LEVEL II (13)

(9) FINAL REPORT

(6) AUTOMATED MANAGEMENT CONTROL SYSTEM
FOR PUBLIC MARINE TERMINALS.
PHASE I. SYSTEM DEFINITION, SYSTEM ANALYSIS,
AND CONCEPT DESIGN.

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LEGAL NOTICE

FOREWORD

Under Contract DO-A01-78-00-3006 with the Maritime Administration, U.S. Department of Commerce, ARINC Research Corporation conducted a project representing the first phase of a multi-phase program to develop and demonstrate an automated management control system for public marine terminals. This report presents the results of the Phase I project, including the definition of system requirements, identification of automation concepts, analysis of cost-benefit relationships, and delineation of activities to be conducted in Phase II.

The successful performance of this Phase I project required cooperation and participation by many persons in the port and marine terminal industry throughout the United States. The individuals who provided access to facilities and information during our survey are too numerous to mention by name, but we acknowledge our indebtedness to them for their patience and assistance. We owe special thanks to the Contracting Officer's Technical Representative, Mr. Kern D. Thorton, and to the members of the Industry Advisory Committee: Messrs. Harvey Blessing, Robert McLaughlin, and Charles Meyers of the Maryland Port Administration; and Messrs. Raymond Brewer, Matthew Marks, and Armando Zanecchia of the Norfolk International Terminal. Their counsel and advice from the viewpoint of the industry was invaluable in assuring that the project addressed real-life problems and provided potentially usable solutions.

EXECUTIVE SUMMARY

ABSTRACT

A project was conducted as the first phase of a multi-phase program to develop and demonstrate an automated management control system for public marine terminals. The objectives of the Phase I effort were as follows:

- Identify the requirements for control of containerized cargo in various categories of public marine terminals;
- Define a family of concepts for an automated management control system that would satisfy the identified requirements;
- Develop and apply a methodology for assessing the impact of various automation concepts on terminal financial performance and operational effectiveness;
- Explore the potential extension of the automation concept beyond the terminal boundaries to permit (1) additional information users, and (2) shared resources, and to
- Develop a detailed plan for implementing Phase II of the overall program. ABSTRACT

The initial activity was to conduct a survey of available information related to control of marine terminals. Published literature on marine terminal operations was searched and reviewed for information on the movement of containerized cargo to ensure that the results of similar previous efforts would be utilized and that the project would not duplicate such efforts. Visits were made to 17 marine terminals at 9 ports to observe terminal operations and interview port and terminal personnel. The ports and terminals visited represented a good cross-section of geography (east, west, and Gulf coasts), operators (port and private), users (single and multiple steamship lines), and operational characteristics (drive-up and walk-up gates, on-chassis and off-chassis yard handling, tower and office control of yard movements, and on-chassis and stacked storage).

It was observed from the survey activity that while terminal layout and ways of doing business vary widely, essentially the same functions are performed and the same data elements used to control and record those functions. In particular, it was noted that some type of central control point exists and is kept informed of every operational action that causes

a change of status of a container, a piece of yard equipment, a storage location, or any other terminal facility associated with the processing and movement of a container within the confines of the terminal.

On the basis of these observations, a basic set of 10 export and 13 import operations was identified as essential to the operation of any container terminal. Seventeen information nodes, or operational stations in the marine terminal involved in sending or receiving operational information, were then identified. Each of the operations was further broken down to define the detailed steps involved, the nodes associated with each step, and the data messages passing between the nodes to initiate each step or record its completion. Individual data elements constituting the messages were identified to analyze the data flow for each operation and each node. The results of these analyses were compiled to represent the requirements for marine container terminal control.

The general concept for automating the terminal control process was defined to consist of a central control system computer (including appropriate software and data bases), receiving data from and transmitting data to a variety of peripheral devices. A set of data files, containing all the data elements associated with operational messages, was identified. Three levels of automation were then addressed -- low, medium, and high -- and system concepts associated with each level were defined. Guidance was prepared for determining the types of hardware appropriate for each level of automation and for identifying the specific characteristics of a particular marine terminal that influence the configuration of an automated system. To aid in understanding the concepts presented, a description of the conceptual operation of an automated system at a typical marine terminal was prepared.

A methodology was developed to assess the costs and benefits associated with the acquisition and operation of an automated system over its useful life. Both quantitative and qualitative benefits were addressed. Quantitative benefits, which could be expressed in terms of direct cost savings for the terminal operator, were the following:

- Reduction in data-handling work force
- Increase in productivity of yard forces
- Reduction in container rehandling due to data errors

Qualitative benefits expected from an automated system were addressed for the following areas:

- Improved operations planning
- Improved reporting
- Improved utilization of terminal resources
- Reduced gate queues
- Increased throughput
- Improved business information

Mathematical models for computing life-cycle costs and quantified benefits were developed. These models were then exercised, with representative marine terminal values being used for the variables, to compute a set of life-cycle costs and benefits that are believed to encompass a broad range of cases applicable to most public marine terminals. Three hypothetical marine terminals were defined, representing small, medium, and large in terms of container throughput capacity. Low, high, and intermediate values of parameters in the benefit models were selected for each of the hypothetical terminals.

The results of the model exercises showed that an automated marine terminal management control system should more than pay for itself during its useful life. For extremely conservative (minimum case) assumptions regarding system costs and potential savings in terminal operating costs, the analyses show a break-even ranging from 3 to 9 years and a rate of return on investment ranging from 15 percent to almost 49 percent, depending on container throughput capacity. These results were computed for hypothetical marine terminals, but the terminal characteristics used are believed to be representative of a broad range of actual terminals.

In addition to the benefits to be realized within the marine terminal as a result of installing an automated system, the consequences of extending the automated concept beyond the boundaries of the terminal itself were explored. Two basic types of extension were considered:

- The use of information associated with container terminal control for exchange with parties outside the terminal
- The sharing of computer resources by multiple users on either a geographic or a corporate basis

Advantages and disadvantages were identified for each type of extension.

The final activity of the project was preparation of a program plan for the next phase of the program, which includes the design of a prototype system, installation and operation of the prototype at an actual public marine terminal, and evaluation of the operation during a demonstration period. The tasks to be performed were defined, together with the schedule and the roles of the various participants (MarAd, the public terminal, and the system architect contractor).

Major conclusions reached on the basis of the project results are summarized as follows:

- It is feasible to configure an automated (computerized) system for controlling the flow of containerized cargo through a marine terminal.
- An automated control system must provide:
  - Central control of information flow
  - Timely acquisition and transmission of data

  - Storage of current status information
  - Access to data for a variety of uses

- Preliminary cost-benefit analyses have shown an extremely favorable relationship between benefits and costs and an attractive rate of return on investment.
- An automated terminal management control system can provide the basis for establishing electronic exchange of data with carriers, shippers, and various other agencies outside the marine terminal.
- A MarAd decision to proceed with a Phase II demonstration is justified

Recommendations for future actions are summarized as follows:

- MarAd should proceed with a Phase II demonstration of a medium-level automated system at a public, multi-user terminal.
- Efforts should be initiated to foster the development of means for electronically exchanging data between the marine terminal and the carriers (water and land), shippers, and other agencies in the port.
- The concept of a nationwide exchange of container location and status data should be investigated to determine its feasibility and the steps necessary to carry it forward.

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CHAPTER ONE

INTRODUCTION

This report presents the results of work performed by ARINC Research Corporation for the Maritime Administration, U.S. Department of Commerce, under Contract DO-A01-78-00-3006. The Contracting Officer's Technical Representative was Mr. K. D. Thornton of the Office of Port and Intermodal Systems. The contract period was 30 September 1977 to 30 September 1978.

1.1 BACKGROUND

The Maritime Administration (MarAd) is vitally interested in fostering innovative applications of technology that will benefit the U.S. port industry as a whole and enhance the industry's ability to stimulate international trade. To this end, MarAd sponsors research into promising technological developments in areas that have broad industry applications but would be too costly for individual ports or marine terminals to pursue independently. Many of these research efforts are jointly supported, with resources contributed by both MarAd and industry in the form of funding, manpower, and facilities.

In recent years, MarAd has taken note of numerous activities being conducted to improve the effectiveness of marine terminals. The rapid growth in waterborne trade, particularly with respect to containerized cargo, has caused many terminals to reach a saturation point, placing a limit on the trade that can be handled. Extreme congestion and inefficient methods for controlling cargo storage and movement have caused terminal operating costs to skyrocket, resulting in higher rates for services rendered and concomitant loss of business for the terminal and port. This is particularly true of public terminals, among which steamship lines and shippers have relative freedom of choice as to the port of embarkation and debarkation for their ships and cargo.

One approach to relieving congestion and improving service is to expand terminal facilities (e.g., add berths, truck gates, and storage space). Waterside land is scarce and, where available, costly to develop. An alternative to facility expansion is to use the present terminal resources more efficiently. The project described in this report represents the investigation of one means for doing so: the enhancement of marine terminal operations through application of an automated management control system.

For purposes of this investigation, a marine terminal automated management control system has been defined as follows:

> A system that employs modern computer, communications, and peripheral equipment technology to enhance the collection, handling, and dissemination of information necessary to expedite and control the flow of cargo through a marine terminal.

1.2 OBJECTIVES

The effort described in this report was concerned with the first phase of a multi-phase program to develop and demonstrate an automated management control system for public marine terminals. The specific objectives of this Phase I effort are as follows:

- Identify the requirements for controlling containerized cargo in various categories of public marine terminals
- Define a family of concepts for an automated management control system that will satisfy the identified requirements
- Develop and apply a methodology for assessing the impact of various automation concepts on terminal financial performance and operational effectiveness
- Explore the potential extension of the automation concept beyond the terminal boundaries to permit (1) additional information users and (2) shared resources
- Develop a detailed plan for implementing Phase II of the overall program

If, as a result of this project, a decision is made to proceed with subsequent phases, the following objectives are currently conceived:

- Phase II - Procure and test one or more prototype systems to demonstrate the feasibility of automated management control system concepts
- Phase III - Develop specifications for an operational system and prepare a package documenting the techniques to be used by the marine terminal industry in evaluating financial and effectiveness considerations associated with specific terminal-system acquisitions.

1.3 DESCRIPTION OF TASKS

The tasks performed to meet the objectives stated in Section 1.2 are described by the following task statements, extracted from the contractual statement of work:

Task I-1: Establish the full range of requirements for public marine terminal control systems. This will be accomplished by

determining the documentation information flow and the various activity control requirements of intermodal, containerized cargo terminals.

Task I-2: Define and develop a family of automated terminal management control concepts that will satisfy all portions of the system requirements defined in Task I-1.

Task I-3: Develop one or more cost analysis models that can be employed to evaluate the financial impact of automated terminal management control systems for the different categories of marine terminals.

Task I-4: Assess the impact of the developed automated terminal management control system on marine terminal financial performance and the effectiveness measures associated with the terminal control activities.

Task I-5: Explore the potential extension of automated terminal management control system concepts beyond the boundaries of the terminal. Two important aspects of this task will be to explore the needs of inland carriers and shippers and the design of a single automated terminal management control system to serve multiple carriers.

Task I-6: Develop a detailed plan, based on the findings of Phase I, which describes the specific testing and operations activities to be conducted in Phase II.

1.4 MARITIME INDUSTRY PARTICIPATION

The participation of the maritime industry was essential to the project to assure that the real needs of the industry would be addressed, that the marine terminal management-control requirements and automation concepts would represent real-word conditions, and that the analysis methodology would provide results that were useful to port and marine terminal managers. Industry participation was provided primarily in three areas: the formation and operation of an Industry Advisory Committee, a series of on-site survey visits to numerous coastal ports and marine terminals, and the presentation of project objectives and progress to key groups representing the maritime industry.

The following subsections describe these areas in greater detail.

1.4.1 Industry Advisory Committee

An Industry Advisory Committee was formed at the beginning of the project to provide guidance and advice, representing industry viewpoints, to the project team. The Ports of Baltimore and Norfolk were invited to participate on the committee because of their proximity to Washington, D.C., and the resultant ease of convening meetings at locations relatively convenient to all participants.

The committee was composed of the following members:

- MarAd - Kern D. Thornton (Chairman)
- Maryland Port Administration - Harvey Blessing, Robert McLaughlin, Charles Meyers
- Norfolk International Terminal - Raymond Brewer, Matthew Marks, Armando Zanecchia

The membership was selected to represent the viewpoints of terminal and port management, terminal operations, finance, and data processing.

Initial meetings were held with the committee members to discuss the project plan; meetings were periodically convened for consultation with the committee members and review of the progress and specific results of the project. Copies of the project monthly progress reports were distributed to the committee for their review and comment.

The charter under which the committee was formed is presented in Appendix A.

1.4.2 On-Site Surveys

On-site survey visits were made to 17 marine terminals at 9 coastal ports on the east, west, and Gulf coasts of the United States. A comprehensive discussion of the terminals visited and the survey activity is presented in Chapter Two of this report. It is mentioned here because, in addition to the specific information obtained and observations made, the survey afforded an excellent opportunity for maritime industry personnel to provide guidance and support to the project team in furthering the objectives of the project.

1.4.3 Presentations to Key Maritime Personnel

During the course of the project, the project team had the opportunity to meet with numerous maritime industry personnel and make both formal and informal presentations of the objectives and progress of the tasks. These meetings each provided an excellent forum for the exchange of ideas and viewpoints and assured that the project team's efforts would continue to address "real world" industry concerns. They also provided a means of keeping industry informed of MarAd's objectives and gaining industry support of the overall program.

Table 1-1 is a summary of the presentations made during the project.

Table 1-1. PRESENTATIONS TO KEY MARITIME PERSONNEL

Date	Audience	Location
10/10/77	MarAd Program Manager	Annapolis, Maryland
10/27/77	Industry Advisory Committee (NIT Members)	Norfolk, Virginia
11/3/77	Industry Advisory Committee (MPA Members)	Baltimore, Maryland
12/1/77	North Atlantic Ports Association	Washington, D. C.
1/10/78	Port of Oakland Terminal Operations Committee	Oakland, California
3/8/78	MarAd Management and Industry Advisory Committee	Washington, D. C.
4/21/78	Port Director and Staff, MASSPORT	Boston, Massachusetts
5/11/78	MarAd Program Manager	Annapolis, Maryland
6/30/78	MarAd Conference on Port Data and Computer Applications	Washington, D. C.

1.5 REPORT ORGANIZATION

The results of the project activities are presented in the remainder of this report, which is organized as follows:

- Chapter Two describes the activities conducted during Task I-1, leading to the definition of the requirements for control of container movements on a public marine terminal.
- Chapter Three describes the activities of Task I-2 and presents the concepts for automating portions of the marine terminal control process.
- Chapter Four outlines the methodology, developed jointly during Tasks I-3 and I-4, for assessing the costs and benefits associated with an automated terminal management control system. The results of preliminary analyses using the models that constitute the methodology are also presented in this chapter.
- Chapter Five presents the results of Task I-5, an exploration of the potential for extending the concept of an automated management control system beyond the terminal boundaries.
- Chapter Six outlines a preliminary program plan prepared in Task VI for Phase II of MarAd's overall automated terminal management control system program. A final program plan, representing the joint efforts of MarAd and the industry participants, will be prepared at the beginning of Phase II.
- Chapter Seven presents the conclusions and recommendations resulting from the project.

CHAPTER TWO

CONTAINER TERMINAL CONTROL REQUIREMENTS

The purpose of Task I-1 has been to define a set of requirements for the control of containerized cargo moving through a marine terminal. These requirements address all of the physical operations that take place at a typical terminal and the information or data associated with initiating, controlling, and recording such operations. This chapter addresses the survey activities performed to obtain basic data and information on requirements, the general characteristics of container terminal operations, and the approach taken in defining the requirements.

2.1 SURVEY ACTIVITIES

The initial step in defining the requirements for control of marine container terminals was to conduct a survey of available information. Published literature was reviewed, and representative ports and terminals were visited. The following subsections describe the documents reviewed, the approach taken in visiting ports and terminals, and the characteristics of the specific terminals visited.

2.1.1 Literature Review

Published literature on marine terminal operations was searched and reviewed for information on the movement of containerized cargo. The purpose of this review was to ensure that the project efforts would take advantage of similar efforts previously performed and documented and would not duplicate such efforts. The principal literature sources were the following:

- MarAd reports and publications
- Port authority reports and publications
- Trade journals and periodicals
- National Technical Information Service
- Manufacturers' reports and product literature

Appendix B is a bibliography of the documents assembled and reviewed (in whole or in part).

2.1.2 Port and Terminal Visits

To ensure that the terminal control requirements were representative of a wide cross-section of typical marine terminals, survey visits were made to a sample of ports and terminals for on-site observations and discussions. The following ports were selected by MarAd to provide a representative mix of geographic location, traffic volume, and operational characteristics:

- East Coast
  - Boston
  - New York/New Jersey
  - Baltimore
  - Norfolk
- West Coast
  - Seattle
  - Oakland
  - Los Angeles
  - Long Beach
- Gulf Coast
  - New Orleans
  - Houston

Representatives of each port were contacted to arrange for the survey visits, and an itinerary was prepared to ensure economy of project staff time and travel costs. It was not possible to arrange a mutually convenient schedule for visiting New Orleans, and that port was subsequently dropped from the survey sample.

The 9 ports, encompassing 17 terminals, are depicted in Figure 2-1, which shows that visits were geographically well distributed at seaports on the west, east, and Gulf coasts of the United States.

Before the ports were visited, an interview packet was prepared so that the survey team could obtain complete and consistent information at each port while minimizing the demands on port and terminal personnel. A copy of the interview packet is presented in Appendix C.

Upon arrival at each port, the survey team met with port and terminal management personnel to discuss the purpose of the survey and select the specific terminals to be visited in the port. Then, using the interview packet, the team conducted detailed discussions of the characteristics of each terminal with respect to ownership, size, facilities, traffic volume, and operating practices. On-site observations of terminal operations were made and notes were taken for later use in defining terminal control requirements.

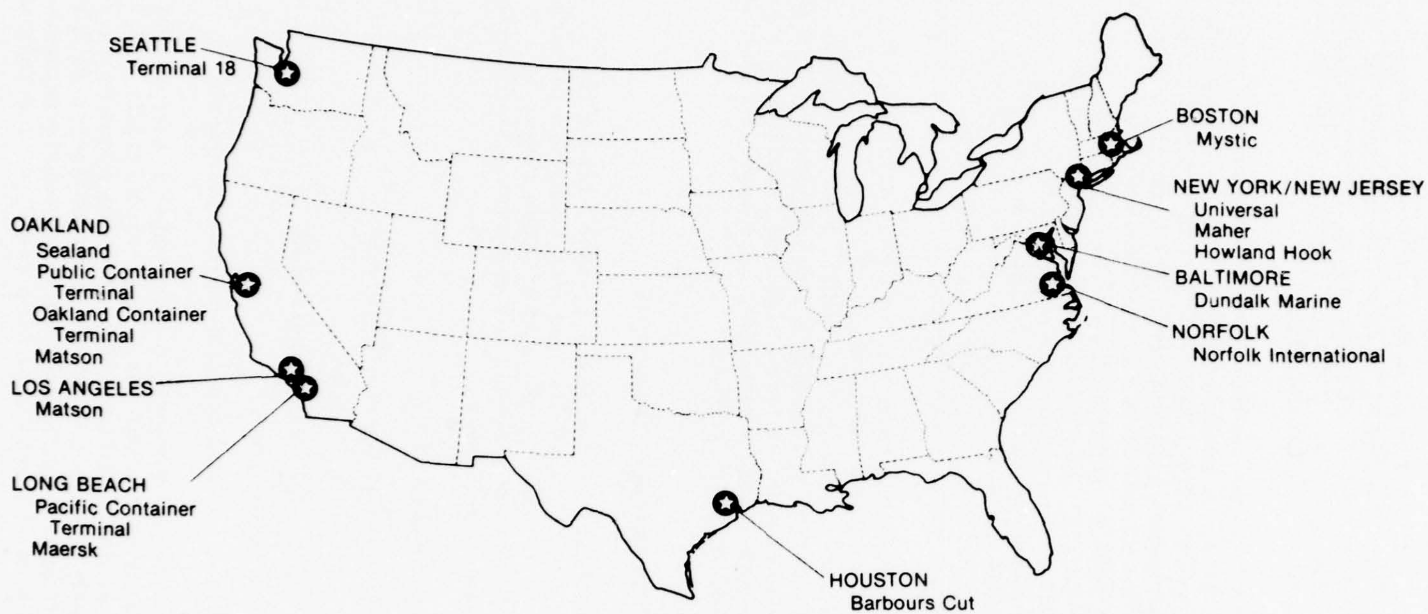

Figure 2-1. PORTS AND TERMINALS VISITED

Table 2-1 lists the principal characteristics of the 17 terminals visited -- those determined to have the greatest influence on the nature of the container control process and on the configuration of a system for automating that process. The significance of these characteristics is discussed further in Chapter Three.

The third column of Table 2-1 identifies the operating responsibility for each terminal -- port authority ("Port"), steamship company ("SS Co."), or private third party ("3rd Prty"). The fourth column indicates whether the terminal serves a single shipline or multiple lines. The fifth column identifies the nature of the gate-house operation. In the sixth column the predominant mode of container handling within the terminal yard is classified as on-chassis ("On Ch."), e.g., hustlers, transtainers, etc., or off-chassis ("Off Ch."), e.g., straddle-carriers. The seventh column shows whether movements within the terminal are controlled from a tower or from an office. In column eight the predominant container storage method is noted: on-chassis, on-deck, or a mixture of both. The final column indicates the extent to which the terminal control process is currently computerized.

It is emphasized that the terminals listed in Table 2-1, and therefore those included in the survey activity, represent a good cross-section of characteristics in all areas. Thus a good base was provided for definition of terminal control requirements representative of a wide variety of terminals. It should also be noted that the cooperation and assistance provided by all port and terminal personnel were excellent and were instrumental in assuring useful survey results.

2.2 CONTAINER TERMINAL OPERATIONS

It was observed that while terminal layout and ways of doing business vary widely, essentially the same functions are performed and the same data elements used to control and record these functions. For the analysis of the terminal control process, the operations involved were grouped into the following functional areas:

- Gate Operations
- Intra-Yard Container Operations
  - Container Storage
  - Intra-Yard Vehicle Control
- Apron Operations
- Customs and Related Government Operations

To provide a framework for analyzing these operations, an idealized container terminal layout was constructed (Figure 2-2). This layout includes all of the functions that might be found at any given terminal and therefore serves as a convenient means of analyzing various scenarios of container flow through various terminal configurations. Figure 2-3 illustrates one such scenario depicting the flow of a full container load, and

Table 2-1. CHARACTERISTICS OF MARINE TERMINALS VISITED

Port	Terminal	Operator			Users		Gate House		Yard Handling		YardControl		Yard Storage		Computer Control	
		Port	SS Co.	3rd Prty	Single	Multiple	DriveUp	Walk Up	On Ch.	Off Ch.	Tower	Office	Chass.	Deck	Yes	No
Norfolk	Norfolk International			x		x	x		x			x	x	x	x	
Baltimore	Dundalk Marine	(1)	(1)	(1)		x	(2)	(2)	x	x		x	x	x		x
	American Export		x		x			x		x		x		x	Partial	
	PRMSA		x		x			x	x			x	x		Partial	
NY/NJ	Universal			x		(3)	(2)	(2)	x			x	x			x
	Maher			x		(3)	x		x			x	x	x	x	
	Howland Hook			x		(3)	(2)	(2)	x			x		x	Partial	
Boston	Mystic	x				x	(2)	(2)	x		x			x		x
Oakland	Sealand		x		x		(2)	(2)	x			x	x		x	
	Oakland Container Terminal			x		(3)	x		x			x		x	x	
	Public Container Terminal			x		x		x		x		x		x		x
	Matson		x			(3)		x		x	x	x		x	Partial	
Seattle	Terminal 18	(1)		(1)		x	x			x	x	x		x	x	
Los Angeles	Matson		x			(3)	x			x	x	x		x	Partial	
Long Beach	Pacific Container Terminal			x		x	(2)	(2)		x		x		x		x
	Maersk		(1)	(1)	x			x	x			x	x		Partial	
Houston	Barbours Cut	x				x	x		x		x			x	x	

Notes: (1) Terminal operations responsibility shared by parties shown.
(2) Gate house functions divided; some on drive-up basis and some on walk-up.
(3) Number of users is limited; not open to public usage.

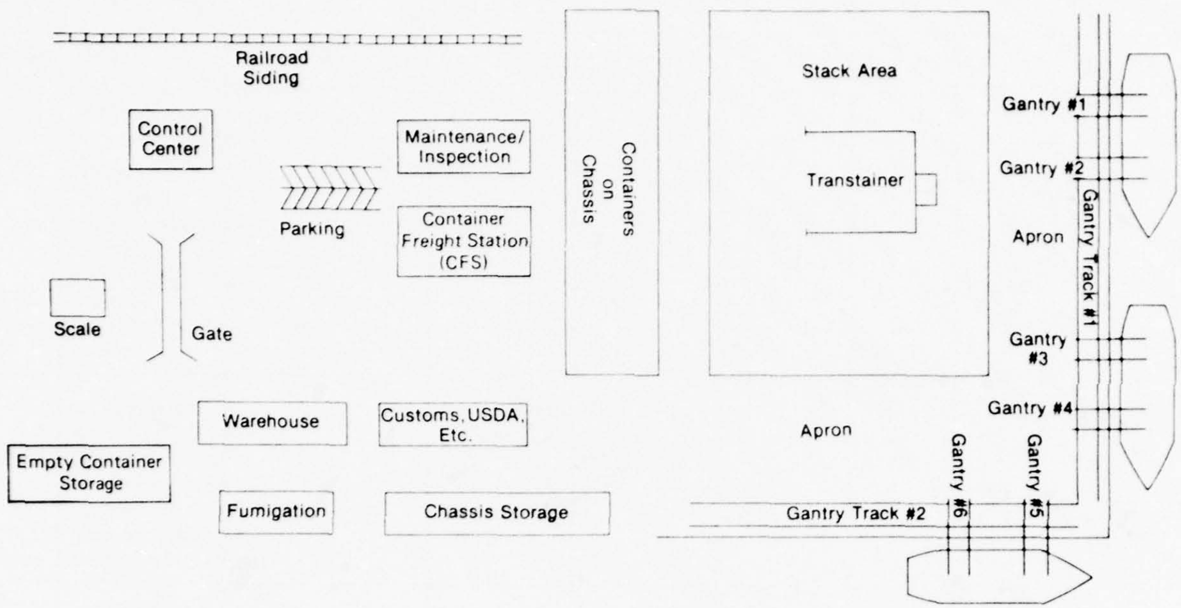

Figure 2-2. IDEALIZED CONTAINER TERMINAL

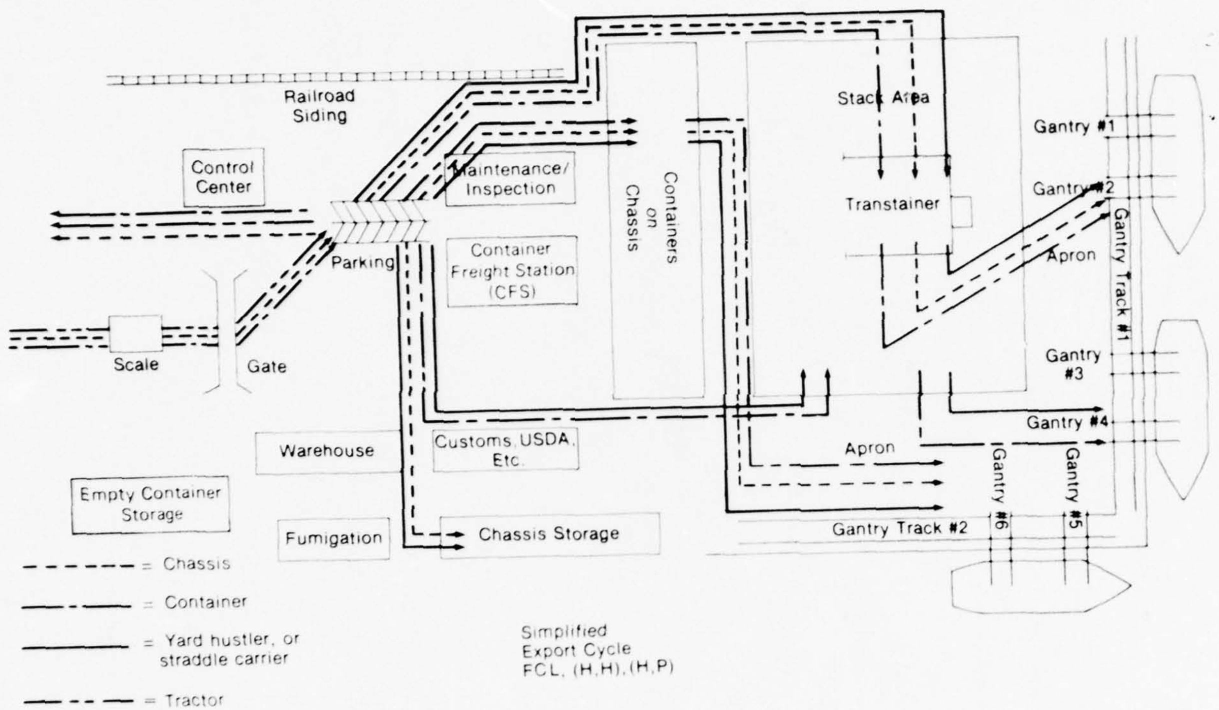

Figure 2-3. IDEALIZED CONTAINER TERMINAL WITH SAMPLE FLOW SCENARIO (EXPORT; FULL CONTAINER LOAD)

4.1.4 ATCS LCC Model (Tax Effects Included) 4-5

associated handling vehicles, through an export cycle. Typical export and import scenarios were employed, with the layout of Figure 2-2 being used, to arrive at the complete set of container terminal operations.

The following subsections summarize observations made during the terminal survey visits, providing the background for subsequent definition of terminal control requirements.

2.2.1 Gate Operations

Operations at the gate area generally include:

1. Weigh-in or, in some cases, presentation of legal proof of weight
2. Inspection of container and chassis, if appropriate
3. Execution of equipment interchange agreement, if appropriate
4. Presentation, by driver, of booking number for empty container pickup
5. Directions given to driver relating to yard destination for pickup or delivery
6. Verification of customs clearance and shipline release of import cargo

The first three gate operations listed are in most cases time-consuming. The data are usually recorded manually, and the appropriate document copies are transmitted to a control point or data input center by messenger or pneumatic tube. When more than one steamship line is using the terminal, interchange is frequently complicated by each line's insisting that its own interchange form be used.

Some variation was observed in the procedures associated with the fourth gate operation, allowing the pick-up of an empty container by a trucker. In many cases, the container is released against an export booking number. A container may, however, be released upon presentation of a memorandum directing stuffing at an inland point. Instances were observed wherein the driver did not need a formal document, only knowledge of the booking number itself, which gate personnel verified by telephone.

The fifth gate operation, determining where a truck driver is to go -- to pick up or deliver a container -- and telling him how to get there, represents probably the most variable practices observed in the study. In some of the simpler manual operations, an operator in a tower has before him a graphical model of the yard; he can make changes by adding, removing, or changing container models on his board. He typically is in contact with the gate and yard personnel by radio or telephone and directs the truck driver where to go. A complaint frequently heard from terminal personnel was that drivers unfamiliar with a particular terminal yard were apt to go to the wrong area and get generally "lost". In one instance, when trucks were arriving in an almost continuous stream in support of an unscheduled quick-turnaround ship operation, this tendency of drivers to go astray had

a deleterious effect on an otherwise smooth and efficient operation. The situation underscored the need for a terminal control system to provide good traffic control and communications.

More sophisticated terminal control systems may employ a computer to make container storage allocations based on such factors as the following:

- Steamship line
- Vessel booked
- Sailing date or voyage number
- Container weight, length, and type
- Destination port

Computer-generated loading sequences and stowage plans may also be produced by advanced control systems.

Before an import container is released, certain checks must be accomplished:

- Is the driver authorized to pick it up?
- Has the steamship line received payment for freight charges, or has it released the cargo on some other basis?
- Has the cargo been cleared by customs and all other interested government agencies?

Security is a major issue here; and, once again, wide variations in procedure were observed. In some instances fairly strict practices were observed, e.g., photographing the driver and his license on entry and using elaborate time- and position-tracking procedures when the truck is in the yard. Other terminals are less structured in this regard.

Release of the cargo by the shipline or its broker may be accomplished in a number of ways. A "dock release" or similar document may be delivered by the shipline to the terminal operator (if other than the shipline); coupled with an interchange agreement, this constitutes clearance to leave. Procedural details in this area depend largely on the shipline-terminal relationships.

Concerning this sixth gate operation, it is important to note that not all import containers are inspected by customs (e.g., inspection may be limited to a sample of one or two containers from a multi-container shipment), but all must be released by customs. This release is recorded legally on customs Form 3461 (revised). How this form is used -- i.e., entered into a computer for automated generation of a container pass or similar document, or hand-carried and surrendered at the gate -- is, again, a matter of local organization.

2.2.2 Intra-Yard Operations

Intra-yard operations are perhaps the most variable of all. Several factors interact to produce this variability:

- Space available in the yard
- Number of operators, i.e., users
- Individual philosophy of the operator

The available space is the principal determinant of how the containers will be stored and what means will be used to move them into and out of storage. A large parking yard, for example, makes it possible to store containers on chassis. This method of storage has several advantages over storage in stacks:

- The container does not have to be handled between chassis and stack.
- Movement of the container is effected simply by hooking up the chassis with a yard hustler.
- Containers are never covered by other containers that may have to be moved to gain access to the desired container.

There are disadvantages as well, including the following:

- A large capital investment must be made in chassis that are not available for other uses.
- On-chassis storage may require extensive real estate, which is usually quite costly.

Combined storage methods were observed at a number of terminals visited, where containers to be stored for comparatively long periods are placed in stack areas while those scheduled for quick movement may be left on their chassis.

There are two principal ways to move containers into and out of a grounded storage area or stack. The method used, transtainer or straddle carrier, depends partly on the space available. As a general rule, a transtainer can stack containers higher than can a straddle carrier, thus achieving greater density of container storage capacity per acre. This advantage must be weighed against the fact that the transtainer is far less mobile than the straddle carrier and usually operates in a relatively fixed area or range. Containers are brought to and removed from the transtainer vicinity on chassis by yard hustlers or, in some cases, by the highway carrier's over-the-road tractor.

There are disadvantages to the use of the straddle carrier. As already mentioned, they are less storage-space efficient than the transtainer. In addition, because of their size and, in some cases, limited driver visibility, they are dangerous to yard personnel. Because the straddle carrier's legs are close to the side of the container, damage to the containers is not uncommon.

The number of shiplines using a terminal can have a powerful impact on how containers are stored and moved, and this impact is related to how the available terminal acreage is apportioned or distributed among the shiplines. There are two general ways in which this distribution may take place. One way is for a particular shipline to lease, or have assigned to it on a more or less permanent basis, some part of the terminal acreage (and perhaps a certain berth). In effect, each such shipline operates its own terminal. On the other hand, the lines may have a sharing arrangement by which the terminal operator assigns berths as required while at the same time performing all necessary actions in the movement and storage of containers.

The shared-terminal approach is probably more efficient of land usage and is preferred by a number of terminals. On the other hand, some shiplines, for reasons relating to security, intensity of operations, and general business practice, prefer to operate in their own self-contained area. The allocation of space on this dedicated basis somewhat reduces the overall efficiency of facilities utilization since each enclave may have space or container movement facilities in surplus while a neighboring one is short of one or both.

Finally, it has been observed that terminal operators or shiplines with apparently similar requirements will choose to satisfy them differently in their approach to terminal operations. In the absence of a detailed optimality analysis, it is difficult to attribute these differences to other than variation in approach or "philosophy".

2.2.3 Apron Operations

The physical act of moving containers onto and off a ship (stow and discharge, or load and unload) is fairly standardized. The container is almost always moved by a gantry crane between stowage location in the ship and the apron. Movements on the landward side of the apron are subject to the same considerations discussed in Section 2.2.2. There are variations in responsibility for operating the crane and other machinery. In public terminals it is not uncommon for the terminal to own the cranes, although in some cases the shiplines have their own cranes. In general, the stevedore is responsible for moving the cargo between the ship's stowage location and the point of rest in the yard, and his personnel may therefore operate the cranes.

There are several specific items of information needed for import and export operations at the apron. When a ship arrives at a container berth, cargo typically will be both discharged from and stowed aboard the ship. Further, the ship's stowage arrangements upon arrival are usually consistent with vessel stability. Under these circumstances an unloading plan will have been prepared which lists, by hatch and hold location, the order of container removal. As each container comes off the ship, a list is prepared to record the container number and its storage disposition in the yard. This list is subsequently compared with the ship's manifest.

After the ship arrives, information on the containers to be discharged, together with a list of containers awaiting shipment (including their destination, weight, and size), is used to prepare an outbound stowage plan. From this stowage plan a loading-sequence list is prepared to coordinate the movement out of yard storage onto the apron in a sequence compatible with the stowage plan.

The loading- and unloading-sequence lists, properly used and witnessed, can become tally sheets to be used in the legal transfer of responsibility for the containers.

2.2.4 Customs and Other Related Government Operations

Customs operations affect import cargo primarily. The ship's manifest is delivered to a customs official, who ascertains which containers are to be inspected and determines the duties on each container. All import containers must be cleared by customs before they can be delivered from the terminal. It is essential that the status (cleared or uncleared) of all containers be tracked so that no uncleared containers will be inadvertently allowed to leave the yard. To achieve this objective, it is necessary that the container's status be known at all times and be properly documented.

Other government agencies (e.g., Internal Revenue Service, Department of Agriculture, Bureau of the Census, etc.) sometimes have a role in inspecting or otherwise affecting the disposition of certain shipments. These agencies function similarly to customs in their interaction with the terminal operator.

2.2.5 Summary

This section has described the general nature of the operations involved at a marine container terminal. To define the requirements for control of the terminal operations, it is necessary to identify in detail the steps in each operation and the information necessary to initiate, complete, and record each action. Section 2.3 describes the approach taken in defining the control requirements.

2.3 REQUIREMENTS FOR CONTAINER TERMINAL CONTROL

The approach to defining the detailed requirements for container terminal control was to identify (1) the detailed operational steps involved in processing containers through a terminal; (2) the information content associated with initiating, controlling, or recording each of the steps; and (3) the information nodes, or points where information is originated or received, and the rate of flow of information between these nodes. The following subsections describe the basic operations, the data elements comprising operational messages, and the flow of data between operational nodes.

2.3.1 Basic Operations

Table 2-2 lists a group of basic export and import operations essential at any container terminal. Each operation has been assigned a number for ease of reference in later analyses. The list is divided into those operations pertaining to export containers (1 through 10) and those pertaining to import containers (11 through 23). It should be noted that some of the listed operations are not performed for all containers; it was intended, however, that the lists include all of the basic operations for any particular terminal.

Table 2-2. LIST OF CONTAINER TERMINAL BASIC OPERATIONS

Operation	Reference Number
Export	
Weigh-in	1
Bobtail in for empty container and chassis	2
Rail car unloading	3
Full container from parking area to storage	4
Gate admittance	5
Interchange	6
Dock receipt execution	7
Full container from storage to apron	8
Empty container to CFS to full container storage	9
Ship loading	10
Import	
Rail car loading	11
Full container from fumigation to storage	12
Full container from storage to fumigation	13
Full container from storage to customs	14
Full container from customs to storage	15
Full container from storage to CFS for stripping	16
Empty container from CFS to empty container storage	17
Ship discharge	18
Container from apron to storage	19
Bobtail in for full container and chassis	20
Interchange of import container and chassis	21
Container tagged for customs inspection	22
Release of container by customs	23

Table 2-3 lists the 17 information nodes, or operational stations in the marine terminal identified as being involved in sending or receiving operational information. Each node is assigned a number for subsequent ease of reference. It should be noted that some of these nodes are often combined in different ways depending on the particular terminal involved (e.g., the gate, scale, and interchange stations are frequently combined). For this project, however, they have been separately listed for completeness and ease of analysis. In subsequent analyses the data for combined nodes can be combined as appropriate.

Table 2-3. LIST OF CONTAINER TERMINAL OPERATIONAL NODES

Node Description	Reference Number
Control Center	1
Gate	2
Parking Area	3
Scale	4
TOFC/COFC Ramp	5
Interchange Station	6
Empty Chassis Storage	7
Empty Container Storage	8
Full Container Storage	9
Transtainers	10
Hustlers/Straddle Carriers	11
Container Freight Station	12
Customs/USDA	13
Fumigation Shed	14
Maintenance/Inspection	15
Apron	16
Crane	17

Each of the terminal operations listed in Table 2-2 was further broken down into the detailed operational steps necessary for that operation to be completed; these detailed steps are presented in Appendix D. The tables in Appendix D list the detailed action steps for each basic operation, the type of message (or information transfer) associated with each step, the nodes (operational stations in the terminal) involved in originating and receiving the message, and the data elements contained in the message. The use of these data elements is discussed further in Sections 2.3.2 and 2.3.3.

It should be noted that here, as well as in all subsequent analyses, a central control center is identified as either the originator or the receiver of every operational message. This implies an assumption that is fundamental to the analyses: effective control of marine container terminal operations requires that a central control point be kept informed of

every operational action that causes a change of status of a container, a piece of yard equipment, a storage location, or any other terminal facility associated with the processing and movement of a container within the confines of the terminal. This assumption was justified on the basis of (1) the observation that all terminals visited during the survey had such a control center of some form, and (2) the unanimous opinion of terminal operational personnel interviewed that such a practice is essential if adequate control is to be exercised.

2.3.2 Data Elements

To determine the nature and quantity of information flow associated with the terminal control process, each data element identified in the tables of Appendix D was analyzed with respect to its length (in characters or bytes) and other characteristics as they pertain to a particular operation. These characteristics are displayed, by operation, in the tables of Appendix E.

All of the data elements associated with the 23 export and import operations are summarized in Table 2-4, which lists a mnemonic designator for ease of reference; shows whether the data element is alphabetic (A), numeric (N), or alphanumeric (A/N); notes whether the element is to be coded rather than recorded in "raw" form (including abbreviations such as "AEL" for American Export Lines, "dmgd" for damaged, "rbr gds" for rubber goods, etc.); and gives the expected maximum length of the data element in bytes (characters).

2.3.3 Data Flow

The final step in the requirements definition was to identify the data flow between the control center (Node 1) and the operational nodes associated with each of the basic terminal operations. The results of this analysis are summarized in Table 2-5, in which the reference numbers for operations and nodes are as listed in Tables 2-2 and 2-3, respectively.

Since the container flow rates for the various operations vary among terminals, it is not possible to predict the absolute values of the data flow rates. Even so, Table 2-5 shows the nodes that have a large number of data bytes associated with certain operations. Examination of Table 2-5 identifies the high-volume nodes (other than the control center) as:

- Gate (Node 2)
- Parking Area (Node 3)
- Interchange Station (Node 6)
- Full Container Storage Area (Node 9)
- Yard Hustler or Straddle Carrier (Node 11)

Since the control center is involved in handling data for all container operations at the terminal, the data flow at that node is extremely large and the size of terminal control system must be planned for accordingly.

Table 2-4. SUMMARY OF DATA ELEMENTS

Data Element	Designator	A/N	Form	Maximum Length (Bytes)
Container Data				
Container Number	CNBR	N	Raw	10
Container Tare	CTAR	N	Raw	6
Container Type	CTPE	A	Coded	3
Container Length	CLEN	N	Raw	2
Container Gross Weight	CGWT	N	Raw	6
Container Storage Location	CLOC	A/N	Raw	5
Container Owner/Lessee	COWN	A	Coded	25
Container Height	CHGT	N	Raw	2
Container Status	CSTA	N	Coded	4
Container Condition	CCON	A/N	Coded	150
Number of Container Moves	CMOV	N	Raw	2
How Container Moved (Truck, Rail)	CTRL	A	Coded	1
Chassis Data				
Chassis Number	HNBR	A/N	Raw	10
Chassis License Number	HLNR	A/N	Raw	8
Chassis Tare	HTAR	N	Raw	6
Chassis Type	HTPE	A/N	Coded	3
Chassis Length	HLEN	N	Raw	2
Chassis Owner/Lessee	HOWN	A	Raw	25
Chassis Condition	HCON	A/N	Coded	150
Chassis Storage Location	HLOC	A/N	Raw	5
Chassis Status	HSTA	N	Coded	4
Land Carrier Data				
Tractor License Number	TLNR	N	Raw	8
Tractor Tare	TTAR	N	Raw	6
Carrier (Tractor Owner)	TCAR	A	Raw	25
Shipline Data				
Shipline	SLIN	A	Raw	25
Voyage Number	VNBR	N	Raw	5
Booking Number	BNBR	A/N	Raw	10
Vessel	VESS	A	Raw	25
Ocean Bill of Lading	OCBL	A/N	Raw	10
Manifest Number	MNBR	N	Raw	10
Shipper Data				
Shipper	SHPR	A/N	Raw	25
Shipper's Address	SADD	A/N	Raw	50
Consignee	CNSN	A/N	Raw	25
Consignee's Address	CADD	A/N	Raw	50
Origin	ORIG	A/N	Raw	15
Forwarder/Agent	AGNT	A/N	Raw	25
Broker	BRIN	A/N	Raw	25

(continued)

Table 2-4. (continued)

Data Element	Designator	A/N	Form	Maximum Length (Bytes)
Port Data				
Port of Discharge	PDIS	A	Raw	25
Port of Loading	PRTL	A	Raw	25
Transhipment Port	TRSP	A	Raw	25
Terminal	TERM	A	Raw	25
Terminal Area	TRMA	A	Coded	3
Last Pier Delivery Date	LPDD	A/N	Raw	10
Personnel Data				
Terminal Employee ID	TEID(N)	A/N	Raw	15
Tractor Driver ID	TDID(N)	A/N	Raw	15
Shipline Employee ID	SEID(N)	A/N	Raw	15
Stevedore Employee ID	STID(N)	A/N	Raw	15
Customs Employee ID	CUID(N)	A/N	Raw	15
Document Data				
EIR Sequence Number	NEIR	A/N	Raw	10
Document Number	DCNR	A/N	Raw	10
Seal Number	SLNR	A/N	Raw	6
Weight Ticket Sequence Number	WTNR	A/N	Raw	10
Delivery Order/Dock Receipt Nr.	DONR	A/N	Raw	10
Cargo Data				
Cargo Description	CDIS	A	Raw	200
Cargo Cube	CUBE	N	Raw	5
Hazard Code	HCDE	A	Coded	2
Marks and Numbers	MKNR	A/N	Raw	20
Number of Packages	NRPK	N	Raw	2
Scale Weight	SWGT	N	Raw	6
Cargo Weight	KRWT	N	Raw	6
Type Shipment (HH)(HP)	TSHI	N	Coded	1
Direction (Import/Export)	CDIR	N	Coded	1
Hatch Number	CHNR	N	Raw	1
Freight Charge Status	FCHG	N	Coded	1
Customs Status	CSTA	N	Coded	1
Freight Payer	PAYR	A/N	Raw	25
Bill of Lading Number	BNBR	A/N	Raw	25
Yard Equipment Data				
Yard Equipment Status	YESS	N	Coded	1
Fumigation Shed Status	FSTS	N	Coded	1
Yard Equipment Type	YETP	N	Coded	2
Yard Equipment Serial Number	YESN	N	Raw	5
Miscellaneous Data				
Remarks	RMRK	A/N	Raw	100

Table 2-5. DATA FLOW (BYTES PER CONTAINER) BY OPERATION AND NODE

Operation	Node and Direction[1] 2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		Totals By Operation
	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	To	From	
Export																																	
1						140																											140
2	81	86	13	20							38		5						41	35													319
3								25[2]			25[2] 5						8		8	45													116
4			3	20											3	30			3	30													89
5		108																															108
6										340[2,3] 522																	340[2,3]						1202
7				358																													358
8															3	20			3	60													86
9												25			10	55			26	93		23											232
10																																61	61
11							6	20					25[2]		3	35	3		6	25[2] 45													168
Import																																	
12											3	25			10	35			13	53					3	23							165
13															15	30			18	20					3	13							99
14															15	35			18	30			3	3									104
15											3	20				25			26	43			13	29									159
16															15	35			18	40	13	13											134
17													3	25	3				6	40	3	56											136
18																														95			95
19															15	35			15	50													115
20	566	156		119											25	25			25	36													952
21										313																							313
22																								21									21
23																								28									28
Totals by Node	647	350	16	517	0	140	6	45	0	1175	74	70	33	25	117	360	11	0	226	645	16	92	16	81	6	36	340	0	0	95	0	61	5200

NOTES: 1 - Direction is as follows (except as indicated in Note 2): To = Flow to indicated node from control center (Node 1)
From = Flow from indicated node to control center (Node 1)

2 - Flow from a remote node to another node via control center.

3 - Applies only when faulty container found at interchange.

While the yard hustler and container storage area nodes handle a large quantity of data per container, these data are in the form of short messages (mostly status and dispatch) spread over the period of a container move. It is not likely, therefore, that these nodes would represent data bottlenecks.

For the gate, parking area, and interchange-point nodes, the situation is somewhat different. For example, the interchange station may have to enter as many as 564 bytes for an export container. This is a single-point operation that is time-consuming and thus constitues a potential bottleneck. In addition, there are problems associated with data entry to an automated system since much of the information (e.g., container and chassis condition) is not readily quantifiable. These problems are compounded if the gate is the interchange point, which it frequently is.

2.4 FEATURES OF MARINE TERMINAL MANAGEMENT CONTROL SYSTEM

This chapter has addressed the requirements for management control of the operations carried out at a marine container terminal. These requirements apply whether the control is performed manually (via paperwork) or automatically (via computer technology).

From observations of marine terminal operations and detailed analysis of the operations and associated information flows, we have determined that an effective terminal management control system should include the following key features:

- Central control of information flow regarding the status of containers, yard equipment, storage locations, or any other terminal facilities associated with the processing and movement of containers within the terminal
- Timely acquisition of accurate data from operational nodes in the terminal, and transmission of appropriate data to enhance performance of operations at the nodes
- Storage of current status information on containers, yard equipment, storage locations, and other terminal facilities
- Access to stored information to serve a variety of real-time inquiries and routine reporting requirements

On the basis of the requirements defined in this chapter, concepts for automating various portions of the terminal management control process are explored in Chapter Three.

CHAPTER THREE

SYSTEM CONCEPTS FOR AUTOMATING MANAGEMENT CONTROL OF MARINE TERMINAL OPERATIONS

It was pointed out in Chapter Two that a fundamental assumption underlying the development of requirements for a container-terminal management control system (whether manual or automated) was that there must be a central control point for information associated with every operational action that changes the status of a container, a piece of yard equipment, a storage location, or any other terminal facility associated with the processing and movement of a container. The concepts described in this chapter represent various means for automating the requirements defined in Chapter Two, with the principle of central control being the primary consideration.

The overall concept of an automated management control system is presented in this chapter, together with a discussion of various means for automating portions of the control process and some of the factors that affect the selection of specific automation concepts for a particular terminal. The chapter also describes how an automated system might be applied at a typical marine terminal.

3.1 GENERAL SYSTEM CONCEPT

The general concept of an automated management control system is depicted, in greatly simplified form, in Figure 3-1. The heart of the system is a control system computer (including appropriate software and data bases) receiving data from and transmitting data to a variety of peripheral devices. A simplified schematic of the system, showing the interaction of the major system elements, is presented in Figure 3-2.

For ease of discussion, three levels of automation have been identified: low, medium, and high. These will be discussed further below. The type, size, and capacity of the computer system and peripheral devices will vary for each level of automation, but the general concept will remain as shown in in Figures 3-1 and 3-2. The following sections address each of the major components shown on Figure 3-2 and the effects of the level of automation, where appropriate.

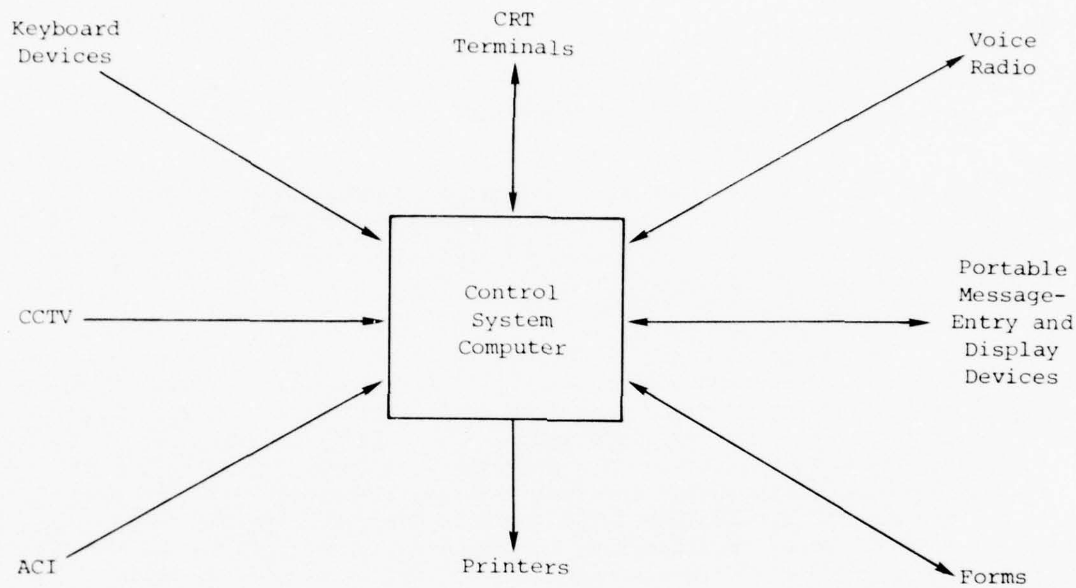

Figure 3-1. SIMPLIFIED SYSTEM CONCEPT

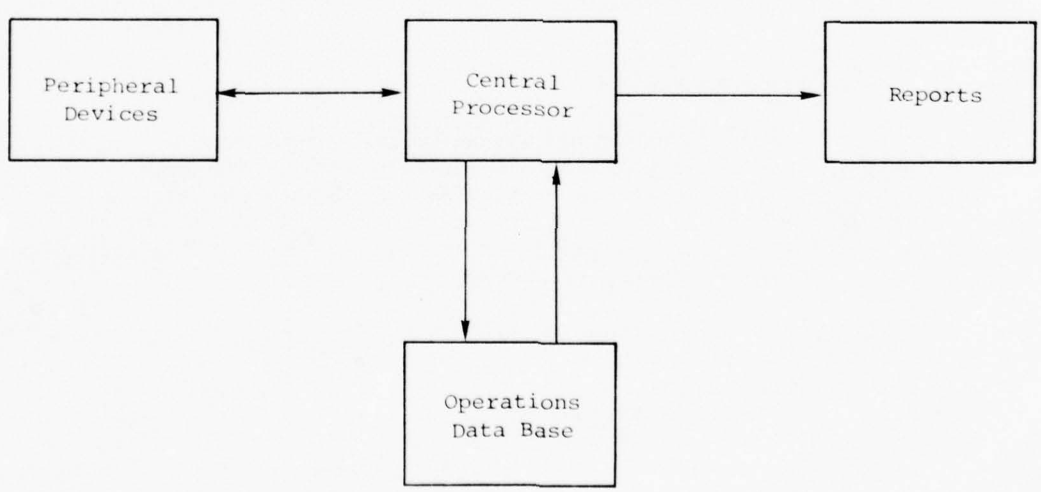

Figure 3-2. SIMPLIFIED SYSTEM SCHEMATIC

3.2 CONTROL SYSTEM CENTRAL PROCESSOR

The control system central processor shown in Figure 3-2 is programmed (1) to interact with a series of data files containing status information on containers and other resources, (2) to provide reports on a routine or as-needed basis, and (3) to accept data from and provide data to various peripheral devices via a communications network.

For a low level of automation, the control system computer would simply be a replacement for a manual filing system. It would be operated in an off-line batch mode, accepting data on a daily or other periodic basis from punched cards, paper or magnetic tape, or direct keyboard entry. It would be capable of providing inventory and transaction information upon command, with such information being representative of the data that had been entered, but not of the real-time status of the terminal. A minimum of peripheral devices would be involved, and communications interface requirements would be minimal.

For a medium level of automation, the system would operate in a real-time, on-line mode, with a high degree of human interaction in the entry and display of data. The central processor would be sized and programmed to provide high-speed access to the data files and response to the peripheral devices. The communications interface would be provided through a multiplexer capable of handling data input and output to the peripheral devices.

In a system having a high level of automation, human interaction would be at a minimum. The central processor would not only provide real-time file access but would also include decision logic capable of generating movement commands and disposition commands for yard equipment and containers on the terminal. The number of peripheral devices engaged in communication of digital data would be greatly increased (as explained later), and a communications processor would be required to assure proper sequencing and routing of messages. If the system were to include voice-recognition data entry, appropriate provisions would have to be made for the translation and processing of voice messages for entry into the central processor and data files.

3.3 OPERATIONS DATA BASE

3.3.1 Listing of Files

The operations data base shown in Figure 3-2 resides in a series of files containing information on containers and various other resources. From a review of the data elements and operations defined in Chapter Two, it was determined that the five files listed in Table 3-1 represent a logical partitioning of data and would provide for all the data elements necessary to configure an automated marine terminal control system. As shown in Table 3-1, files are created to maintain up-to-date records of the location and status of containers and chassis, the status and occupancy

Table 3-1. OPERATIONS DATA BASE FILE LIST	
File Name	Purpose
Container Location File, CLF	Records status and location of containers. This is the principal system file.
Chassis Location File, HLF	Performs same function as CLF, but to a lower level of detail.
Storage Location File, SLF	Records status and occupancy of container and chassis storage-cell locations. SLF, HLF, and CLF will cross-reference one another.
Tractor Location File, TLF	Tracks the road carrier's tractor through the terminal property.
Yard Equipment File, YEF	Records location and status of yard equipment, e.g., transtainers, straddle carriers, hustlers, etc. Purpose is to effect control over these equipments.

of storage-cell locations, the location of road-carrier tractors while on the terminal property, and the location and status of terminal yard equipment involved in container movement.

3.3.2 File Contents

The data elements to be contained in each of the five files listed in Table 3-1 are shown in Tables 3-2 through 3-6. Certain of these data elements may not be available for a given application, in which case the appropriate fields would be blank. The data elements in Tables 3-2 through 3-6 correspond with those identified in Chapter Two and represent all data needed to effect automated control of terminal operations. The data elements are grouped to provide ease of access for data entry and retrieval. It is possible that in a final system design for a particular terminal some regrouping of data elements may be necessary.

3.3.3 Interaction of Data Base with Operations

As previously stated, the general system concept requires that all terminal operations be communicated through a control center; this concept is essential for the data base to be accurate and current.

For a low level of automation (non-real time), transaction and status data would be entered on a periodic, off-line basis. For real-time operation (medium or high level of automation), a high degree of dynamic

Table 3-2. CONTAINER LOCATION FILE, CLF	
For each container in the yard, a record of the following will be kept:	
Container number Container tare Container type Container length Container height Gross weight Current storage location Last storage location Owner or lessee Container status (coded) • Loaded or empty • If loaded, cargo description • Grounded or on chassis • If on wheels, chassis number • If with tractor, tractor license number	Number of containers moved How containers moved (truck/rail) Hazard code Last status Date-time group of yard entry Date-time group of present location Date-time group of last location Date-time group of present status Date-time group of last status
The following fields will be filled as appropriate to the status of the container:	
Pier number (going to or coming from) Shipper Shipper's address Consignee Consignee's address Origin Broker/Forwarder/Agent Terminal Vessel Voyage number Seal number Cargo weight Cargo cube Type shipment Direction Cargo description Freight payer Freight charge status Hatch number EIR sequence number Port of discharge Port of loading	Transshipment port Weight ticket sequence number Delivery order/dock receipt number B/L number Ocean B/L Number of packages Customs status Carrier (trucking company) Tractor license number Tractor Driver I.D.* Terminal employee I.D.* Stevedore employee I.D.* Customs employee I.D.* Shipline employee I.D.* Marks and numbers Shipline Yard equipment serial number Yard equipment type Terminal area Fumigation shed status Last pier delivery date Container condition
*Last person in contact with container.	

Table 3-3. CHASSIS LOCATION FILE, HLF
For each chassis in the yard:
Chassis number Chassis license number Chassis type (coded) Chassis tare Chassis length Current storage location Last storage location Owner or lessee Present status Last status Date-time group of present location Date-time group last location Date-time group of present status Date-time group of last status Chassis condition

Table 3-4. STORAGE LOCATION FILE, SLF
For each storage cell location:
Storage location number Type of storage, i.e., grounded, etc. Status, occupied, etc. Contents • Container numbers • Chassis numbers Date-time group of present status change Date-time group of prior status change

Table 3-5. TRACTOR LOCATION FILE, TLF
For each tractor on the terminal property:
Tractor license number Driver I.D. Tractor type (coded) Tractor tare Location in yard Last location Carrier Status • With or without chassis • If with chassis, chassis I.D. (see CLF) • If with chassis, with or without container (see CLF then CF) Last status Date-time group of present location Date-time group of last location Date-time group of present status Date-time group of last location

Table 3-6. YARD EQUIPMENT FILES, YEF
For each piece of yard equipment:
Yard equipment serial number Yard equipment type Location in yard Last location Status • In service, i.e., up or down • If up, occupational status, i.e., active operation or standby • If active, nature of activity (coded) • If activity involves chassis or container, or both, number of chassis and number of containers Last-status Date-time group of present location Date-time group of last location Date-time group of present status Date-time group of last status

interaction with the data base would be required. In a real-time application, each operational node would enter data every time an action was taken at that node causing a change of status or location of a container, chassis, or other resource for which data files were being maintained. The central processor would cause the appropriate files to be updated so that current information would be immediately available for response to inquiries regarding the status or location of the container or resource, or for automatic display to operational personnel who must act upon it.

3.4 REPORTS

It is important that an automated management control system for a particular terminal be designed to provide both routine and on-demand reports that are responsive to the needs of the terminal operator, port authority, shipline customers, agents/forwarders, and the many other parties who might require information from the system. Virtually any data element that resides in the data base can be extracted in numerous ways to provide information of a historical, statistical, or operational nature.

Typical report categories that might be provided on a daily or other regular basis are the following:

- List of transactions during report period
  - Total for terminal
  - By shipline
- Inventory of containers in storage
  - By storage location
  - By shipline
  - By vessel and voyage
  - By port of discharge
  - By date of receipt
  - By flow direction (export vs. import)
- List of import containers awaiting customs clearance
- List of inventory changes since last report

A great variety of inquiries into the data base can be serviced on demand by providing the necessary software for data base access. The following are examples of the types of inquiries that might be made by various parties:

- All information on hand for a given container
- All containers of a particular type in inventory

- All containers on hand for:
  - A particular shipline
  - A particular booking
  - A particular port of discharge
  - A particular bill of lading
- All containers on hand containing hazardous or dangerous cargo
- All containers on terminal over (x) days
- All containers in a particular storage area
- All unoccupied storage areas available

3.5 PERIPHERAL DEVICES

The portions of the system most subject to variation are the peripheral devices employed to move data into and out of the central processor and data base. The peripheral devices vary not only with the level of automation but also with many other characteristics of a particular terminal.

The following subsections address some of the peripheral devices that might be applicable to each of the three levels of automation at various operational nodes in the terminal, and some of the factors that must be considered in designing a system for a particular terminal.

3.5.1 Low-Level Automated System

Since a low-level automated system has been previously described as an off-line, non-real-time system, the only peripheral devices required are those for providing batch data entry and display. Such devices include paper card or tape punches and readers, magnetic tape drives, keyboards, and printers. Since no real-time communication takes place, there is no need to place peripheral devices at any of the operational nodes in the terminal; data are extracted off-line from interchange receipts, location logs, and other such commonly used sources.

3.5.2 Medium-Level Automated System

In the medium-level automated system, the central processor interacts with the operational nodes and data base on a real-time basis, and a high degree of human interaction is retained. In such a system, two basic operational configurations are possible: centralized data entry and decentralized data entry. In the centralized configuration, all data are communicated to a central point, where they are entered into the data base by a clerk-operator. Source data are communicated physically (hand delivery or pneumatic tube) or vocally (radio or telephone), and the data are entered on a data-terminal device, such as a keyboard with a cathode-ray tube display or hard-copy printer.

In the decentralized configuration, data entry and display devices are located at the various operational nodes for direct interaction with the data base. At the gate, where much data handling is required for processing receipts and deliveries, a high-speed data terminal is applicable. To simplify the entry of data, a so-called "intelligent" data terminal can be installed at the gate. Such a terminal has a built-in microprocessor that permits it to perform some local data processing without tying up the system's central computer. With an intelligent terminal, a blank facsimile interchange receipt form can be electronically displayed on a cathode-ray tube. Appropriate information on the container, chassis, tractor, etc., can be entered on the form by using the keyboard. If any of the needed information has been previously received from the shipper, agent, carrier, or other source, and resides in the operating data base, that information can be automatically displayed in the appropriate section of the facsimile form and need not be re-entered. When the clerk is satisfied that the information on the tube is complete and correct, he can push a button so that the data are entered into the central data base and simultaneously printed on a multi-part interchange receipt form for completion of the interchange transaction with the tractor driver.

In the terminal yard, mobile equipment (e.g., transtainers, hustlers, straddle carriers, etc.) can interact with the data base indirectly or directly. Indirectly, the information (container identification, storage location, vehicle status, etc.) is relayed via radio to a central operator, who interacts with the data base through a data terminal device. With direct interaction, the vehicle driver enters data by using some form of portable digital data entry device, or perhaps by using vocal entry through a voice-recognition word processor that formats spoken messages for entry into the central processor.

Nonmobile locations in the yard (customs, fumigation, LCL freight station, etc.) generally have low data rate requirements; they also are not involved in real-time data handling associated with container moves. For such locations, a relatively low-speed data terminal having keyboard entry and printer will suffice.

3.5.3 High-Level Automated System

In a highly automated system, human interaction is at a minimum. The acquisition, entry, processing, and display of data are automated to the greatest degree permitted by current technology.

Information on incoming containers is provided electronically from shippers or from shiplines. This information forms the basis for building a file on a particular container before it arrives at the terminal. Upon container arrival, a device at the gate or crane automatically reads the container identification marking; this is matched against existing file information to produce the necessary interchange documents and activate the entry of the container into the yard inventory. Any missing information, or information needing correction or updating, is entered through a high-speed data terminal or entered vocally by means of a voice-recognition processor.

Once a container is admitted to the marine terminal, its movement to or from storage or other terminal locations is automatically controlled through logic programmed into the terminal control system. The only human interaction is that necessary to solve exceptional handling problems; routine handling is based on established logic rules. Movement commands are generated by the computer and transmitted to appropriate yard vehicles via remote digital devices; completion of handling moves, in turn, is communicated to and recorded by the central control computer.

3.5.4 Closed-Circuit Television

The use of closed-circuit television at the gate/scale/interchange areas is addressed separately since it could apply to any of the three levels of automation. Although not a true peripheral device, in that it does not interact directly with the computer (except as described later for a high-level automated system), it can be a valuable adjunct to an automated control system. By using properly located high-resolution cameras with remote pan, tilt, and zoom controls, a clerk or interchange inspector can use a centrally located monitor to survey numerous gate lanes for verifying container, chassis, and truck identification and for determining container and chassis condition. This approach offers the potential for significant savings in workload, with possible reduction in work force, and the elimination of errors introduced in transcribing identification numbers during a walk-around inspection.

For a high-level automated system, the television camera can act as the sensor for an optical-character-reading (OCR) system, providing direct input of container and chassis numbers into the central computer system. Currently, OCR systems are being used for special limited applications, and some technology development would be required for the marine terminal application. It is mentioned here as a concept, however, since it holds promise as a possible future component of a marine terminal automated management control system.

3.6 APPLICABILITY OF HARDWARE DEVICES

The applicability of hardware devices for various levels of automation is shown in Table 3-7. The terminal nodes and stations listed in the table correspond with those defined in Chapter Two. For a particular level of automation at a particular terminal, various combinations of hardware are possible.

As can be seen in Table 3-7, a central processor and peripheral devices for input and output at the control center are necessary for all three levels of automation. A communications network controller will be needed for medium and high levels of automation to control the interactive flow of real-time data. Voice radio communications will be needed for all levels of automation, since voice back-up should be provided for even a highly automated system where digital data transmission is the primary mode. A variety of other peripheral devices might be chosen on the basis of specific characteristics of the marine terminal involved.

Table 3-7. APPLICABILITY OF HARDWARE AT TERMINAL NODES FOR VARIOUS LEVELS OF AUTOMATION

Node	Node Number	Central Processor	Communi-cations Network Controller	Intelligent Terminal	Simple Cathode-Ray Tube Terminal	Keyboard	Closed-Circuit Television	Printer	Voice Radio	Mobile I/O Device	Remote Scale Transmitter	Portable Data Entry/ Display Device
Control Center	1	L,M,H	M,H		L,M,H	L,M,H		L,M,H	L,M,H			
Gate, Scale, Interchange	2,4,6			M,H	M,H	M,H	L,M,H	M,H	M,H		M,H	
Mobile Stations: Straddle Carriers, Transtainer, Hustler, Crane	10, 11, 17								L,M,H	M,H		M,H
Parking Area	3								L,M,H			M,H
Customs, USDA	13				M,H	M,H		M,H				
Storage: Empty Chassis, Empty Container, Full Container	7, 8, 9								L,M,H			M,H
TOFC/COFC Ramp	5								L,M,H			M,H
Container Freight Station	12				M,H	M,H		M,H				M,H
Fumigation, Inspection, Maintenance	14, 15								L,M,H			M,H
Apron	16				M,H	M,H			L,M,H			M,H

L = Low-Level Automation
M = Medium-Level Automation
H = High-Level Automation

3.7 FACTORS AFFECTING SYSTEM CONFIGURATION

Although three levels of automation have been defined, it must be recognized that at a particular marine terminal, the complement of hardware for a terminal management control system would represent a mixture of devices that may be representative of various automation levels. Many factors enter into the selection of a system suitable for a given terminal, including traffic volume, terminal area, number of gate positions, and number of berths. In addition to these quantitative factors, certain terminal characteristics were identified during the survey as having considerable influence on the configuration of a terminal control system. These included the nature of the gate operations, the methods used for handling containers in the yard, the type of control center operation, and the philosophy governing yard storage of containers. The following are some of the key influencing characteristics in each of these areas:

- Gate Operations
  - Drive-up gate house versus walk-up operation, or a combination of both
  - Scales integral with the gate lanes or located separately
  - Interchange performed at the gate or at a separate location
  - Level to which container storage assignments are made at the gate (area, row, specific slot, or no assignment)
  - Presence or absence of a railroad ramp (TOFC/COFC) on terminal; if present, interchange accomplished at the ramp or at the gate
- Yard Handling Methods
  - Yard handling of containers accomplished on-chassis (fully wheeled or transtainers and hustlers) or off-chassis (straddle carriers or lifters), or a combination of both
- Yard Control Center
  - Control of container and vehicle movements accomplished from a tower or from an office, or from both
- Yard Storage Philosophy
  - Containers stored on chassis (chassis controlled or not controlled), stored in stacks, or a combination of both
  - Storage space allocated by container attributes (empty or loaded), by cargo attributes (perishable, valuable, hazardous, etc.), by direction of movement (import or export), by steamship company, by vessel/voyage, by port of discharge, etc.
  - Storage allocations made on a permanent basis or on a variable basis (assigned daily or on other basis)

3.8 TYPICAL SYSTEM APPLICATION

To illustrate the application of the concepts described in this chapter, this section describes the conceptual employment of an automated management control system at a typical marine container terminal. It must be acknowledged that there is no such thing as a "typical" terminal; the system configuration and operation for a particular terminal will depend on many factors such as those described in Section 3.7. Further, the degree to which terminal personnel, particularly union personnel, can perform the functions described below will be greatly influenced by local labor agreements and job classifications. Nonetheless, the following description does provide an understanding of how the various elements of an automated system might be integrated in a marine terminal application.

For ease of discussion, the operations described are based on the processing of a full container load bound for export. Similar concepts would apply for an import load; the principal difference would be that precautions must be incorporated to preclude premature release of a container until proper releases have been obtained from the steamship line (freight charges paid), the customs agent (import duties paid), and the terminal operator (demurrage charges paid if applicable). The conceptual system described represents a medium level of automation, employing devices that are readily available within the state of the art.

3.8.1 Gate Processing

On arrival at the gate, the highway tractor driver presents his credentials and papers to a gate man. After checking to assure that the papers are in order and correspond with the arriving container number, the gate man enters the container number on his keyboard device. The central computer searches its files to determine whether prior information has been stored for that container (on the basis of booking information received from the appropriate agent or steamship line). A facsimile of an interchange receipt form is then displayed to the gate man on a cathode-ray tube (CRT) with prior information already entered in the appropriate sections of the form. If no prior information is on file, the displayed form is blank.

The gate man completes the displayed form, using his keyboard, by filling in any missing information necessary to complete the receiving process. Meanwhile, a checker has inspected the equipment and verified the container seal number. The checker notifies the gate man of the results of his inspection, and the gate man makes his appropriate entries through his keyboard. When he has reviewed the information displayed on the CRT and is satisfied that the form is complete, the gate man enters a command that simultaneously causes the entered data to be transmitted to the central computer and a hard copy of the completed interchange receipt form to be issued on a high-speed printer. The gate man detaches the printed interchange receipt, he and the truck driver sign it, and the receiving process is complete.

The gate man then enters a command on his keyboard to receive instructions for the tractor driver's next action. On the basis of decision logic in the central computer, instructions are displayed on the CRT as to where the container is to be delivered. In general, the tractor driver will usually be directed to a temporary parking area so that the container can be transferred to a straddle carrier or yard hustler, or to a specific area or row of the storage yard for parking (wheeled storage) or transfer to a transtainer (stacked storage).

3.8.2 Placement in Storage

Simultaneously with the instruction display at the gate for the tractor driver, a display is created on a CRT at the yard control center showing the container number and its assigned storage location in the yard. The control center operator then dispatches an available yard vehicle (straddle carrier, hustler, or transtainer) by voice radio command to transfer the container to its assigned storage location. When the container has been stored, the yard vehicle operator notifies the control center operator by radio that he has completed the assigned move and is available for another assignment. The control center operator makes a keyboard entry to indicate that the container has been stored as assigned, and the container information is loaded into the central computer's inventory file.

3.8.3 Preparation for Ship Loading

Each steamship line receives daily printout reports of all transactions occurring that involve containers owned by or assigned to that line, as well as information on all of the line's containers currently in the storage inventory. The inventory reports can be arranged in any desired order (e.g., by booking, by port of discharge, by gross weight, etc.). These and other reports can also be produced on demand to report the status at any given time.

When preparing to load a ship that is due to arrive, the steamship line uses current inventory information on containers booked for that ship to prepare a ship stowage plan, showing the specific location for each container in each hatch or deck stowage area. It then prepares a loading sequence, using the stowage plan and taking into account requirements for ship stability during loading. The loading sequence is delivered to the marine terminal, and a clerk enters it into the computer by using magnetic tape, punched cards, or a manual keyboard, depending on the format in which it is received.

3.8.4 Removal from Storage

When a ship arrives and notice to commence loading is given, the control center operator enters a command for the computer to produce a list showing the sequence in which containers are to be removed from storage. The computer searches the inventory file for each container on the prestored loading sequence for that ship and produces a list showing the storage location of each container, arranged in loading-sequence order. The list is displayed on the control center operator's CRT and is simultaneously printed out in hard copy form at the control center and the apron.

The control center operator radio-dispatches available yard vehicles to remove the containers from storage in the order listed and deliver them to the apron for transfer to the gantry crane. As soon as he receives a radio confirmation that a particular container has been removed from storage, he makes an appropriate keyboard entry, and that container is removed from his CRT display.

3.8.5 Loading the Ship

As each loaded yard vehicle arrives at the gantry crane, the crane checker uses the hard copy loading list from the printer at the apron to verify that the proper container sequence is maintained. If a wrong container (not on the loading list) arrives, or a container arrives out of sequence, the crane checker contacts the control center operator by radio and the necessary actions are taken to resolve the discrepancy and restore the proper sequence.

When he has determined that the proper container has arrived, the crane checker signals the crane operator to transfer it from the yard vehicle and notifies him by radio as to its proper stowage location. After the crane operator completes the transfer and stowage operation, the crane checker enters the container number into a portable message-entry device. Upon entry of an appropriate command on the portable device, a message is transmitted to the central computer, causing the container record to be removed from the terminal yard inventory and entered on a magnetic-tape listing of containers loaded for that ship.

When all of the containers on the loading list have been stowed on the ship, a complete magnetic-tape record will be available. That record can be used to create an as-loaded list for the steamship line in whatever form desired: hard copy, magnetic tape, punched cards, etc. The as-loaded list can, in turn, be used by the shipline to verify that the ship was loaded according to the stowage plan and to create the ship manifest.

3.9 SUMMARY

This chapter has presented the basic system concept for automating the terminal management control process defined in Chapter Two. This concept is built around a central processor that interacts with an operations data base, accepting data from and providing data to various peripheral devices, and providing reports routinely or upon inquiry.

Three levels of automation have been examined:

- Low level -- off-line, non-real-time entry and display of data
- Medium level -- on-line, real-time entry and display of data with a high degree of human interaction
- High level -- on-line, real-time entry and display of data with a minimum of human interaction

the location and status of containers and chassis, the status and occupancy

The specific system configuration for a given marine container terminal is highly dependent on a number of key characteristics of the terminal, including the following:

- Nature and configuration of gate operations
- Methods used for handling containers in the terminal yard
- Type and configuration of yard control center
- Philosophy governing methods of storing containers and allocating storage locations

The operations associated with processing a full container load bound for export, using a system employing some of the automation concepts previously discussed, have been described to illustrate the application of those concepts at a typical marine terminal.

In deciding whether to employ an automated system, and what level of automation is appropriate, a terminal operator must consider the cost of acquiring and owning such a system over its projected *life cycle*, as well as the benefits he expects to accrue through its operation. Chapter Four describes a methodology for determining system life-cycle costs and assessing benefits (both qualitative and quantitative), and presents the results of preliminary cost-benefit analyses for a family of representative hypothetical marine container terminals.

data would be entered on a periodic, off-line basis. For real-time operation (medium or high level of automation), a high degree of dynamic

3-4

CHAPTER FOUR

COST-BENEFIT ASSESSMENT

A decision on implementing an automated management control system is made by different marine terminal operators on the basis of sometimes widely different criteria. A publicly owned and operated terminal may operate to achieve a high level of container throughput, while breaking even financially, to stimulate commerce in the hinterland. On the other hand, such a terminal might be operated to achieve some "profit" in order to obtain revenue for the owning state or municipal authority. Certainly, a privately owned and operated terminal would be expected to make a profit. A terminal owned and operated by a steamship line represents a wide range of possibilities; it could be a profitable component of the company, or it could break even or operate at a loss, with operating costs being covered by the line's entire revenue.

In all of these cases, a decision to invest capital in any new system is usually made on the basis of how the investment compares with other opportunities to invest the same funds. The comparison may be in terms of acquisition cost, total life-cycle cost, annualized cash flow, return on investment, or some other economic measure.

The purpose of the analysis described in this chapter was to develop a methodology that would provide the basis for a terminal operator to compute the economic measures needed in making a decision whether to automate terminal management control. Application of the methodology is illustrated by preliminary calculations based on representative marine terminal data.

The cost-benefit methodology presented herein addresses both the life-cycle cost and the potential benefits associated with implementing an automated system. The following sections describe the development of the life-cycle-cost and benefit-assessment models and then present the results of exercising these models for representative marine terminals.

4.1 LIFE-CYCLE-COST MODEL

The purpose of a system life-cycle-cost analysis is to enable the analyst to account for all of the costs associated with purchasing and owning a system over its useful life. The cost categories include acquisition,

installation, operation, maintenance, training, and disposal or salvage. Costs in each category are computed for each year of the system's life; they are adjusted to account for the relative value of the dollar for each year and then summed over the total system life to provide the net present value of the system's life-cycle cost. The effects of tax credits and deductions may be accounted for, depending on the tax status of the system owner.

The following subsections describe the general form of a life-cycle-cost equation, the model derived for this project, and the method used to account for tax effects. Preliminary results of model exercises are presented in Section 4.3.

4.1.1 General Life-Cycle-Cost Equation

The general form of a life-cycle-cost equation is as follows:

$$LCC = A_o + \sum_{t=1}^{L} D^t \, (A_t + I_t + O_t + M_t + T_t + S_t) \qquad (1)$$

where

- LCC = *Life-cycle cost (dollars)*
- A_o = Initial acquisition cost
- L = Useful life of system (years)
- t = Yearly index
- D = Discount factor
- A_t = Acquisition cost in year t
- I_t = *Installation cost in year* t
- O_t = *Operating cost in year t*
- M_t = Maintenance cost in year t
- T_t = Training cost in year t
- S_t = Salvage or disposal cost in year t

The discount factor, D, is defined as

$$D = \frac{1}{1+d} \qquad (2)$$

where d is the discount rate. The U.S. Office of Management and Budget has directed that a discount rate of 10 percent be used for Government-sponsored analyses. The discount factor thus becomes

$$D = \frac{1}{1+0.1} = \frac{1}{1.1} = 0.90909 \qquad (3)$$

and Equation 1 becomes

$$LCC = A_o + \sum_{t=1}^{L} (0.90909)^t (A+I+O+M+T+S)_t \tag{4}$$

4.1.2 ATCS LCC Model (Tax Effects Not Included)

For purposes of this analysis, several assumptions have been made with respect to the cost terms in Equation 4:

- All acquisition costs are assumed to occur at the outset; hence $A_t = 0$.
- All installation costs are assumed to be included in the initial acquisition cost; hence $I_t = 0$.
- Training costs are assumed to be negligible since the system is conceived to be relatively simple for present personnel to operate (allowing a high degree of on-job training), and most system maintenance is expected to be performed under a maintenance contract (requiring vitually no training for maintenance personnel); hence $T_t = 0$.
- The system is assumed to be fully depreciated within its useful life and to incur negligible cost for removal or replacement at end of life; hence $S_t = 0$.

Equation 4 thus becomes

$$LCC = A_o + \sum_{t=1}^{L} D^t (O_t + M_t) \tag{5}$$

It is this form of the model that is used for subsequent analyses in those cases to which tax effects are not applicable.

4.1.3 Tax Effects on Life-Cycle Cost

For a privately owned and operated terminal, the effects of income and other taxes on system life-cycle cost should be considered. Because of the great variations in state and local taxes, it is not possible to include them in this analysis. The effects of Federal income taxes, however, will be explored.

The two principal effects of the Federal income tax, both of which serve to reduce the life-cycle cost incurred by the system, are the tax credit for capital investment and the deduction for capital depreciation. These are addressed in the following paragraphs.

4.1.3.1 Tax Credit for Capital Investment

The Internal Revenue Service (IRS) allows credit against Federal income taxes for investment to acquire certain types of capital equipment or facilities. An automated terminal control system would qualify for such a credit.

The amount of the credit (which cannot exceed taxes owed) depends on the depreciable life of the system, as follows:

System Life (Years)	Tax Credit (Percent of Investment)
Less than 5	3 1/3
At least 5, less than 7	6 2/3
7 or greater	10

For the purposes of this analysis, the investment tax credit is considered as if it were a discount on the acquisition cost, so that

$$A_o = A - AC, \text{ or}$$
$$A_o = A(1-C) \qquad (6)$$

where

A_o = Initial acquisition cost (dollars)

A = Purchase cost (dollars)

C = Factor for investment tax credit

4.1.3.2 Deduction for Capital Depreciation

The IRS also allows a deduction from taxable income for the annual value of depreciation of a capital item. In life-cycle-cost analyses, this deduction is sometimes incorporated into one of the terms in the general equation (Equation 1). However, this is not possible if the system's useful life for depreciation purposes is different from the life-cycle period being analyzed.

The equation for the annual tax deduction for capital depreciation is as follows:

$$(TD)_t = (DC)_t \times R_t \qquad (7)$$

where

$(TD)_t$ = Tax deduction for year t (dollars)

$(DC)_t$ = Depreciable cost for year t (dollars)

R_t = Tax rate for year t (percent)

For purposes of this analysis, the system is assumed to be fully depreciated (no salvage value) at a straight-line rate. Then

$$(DC)_t = \frac{A}{N} \tag{8}$$

where

A = Purchase cost (dollars)

N = Depreciation period (years)

Further, a corporate tax rate of 48 percent is assumed to apply for each year (R_t = 0.48). Equation 7 then becomes:

$$(TD)_t = \frac{A}{N} \times (0.48) \tag{9}$$

Summing $(TD)_t$ for the depreciation period, and adding a discount factor, yields the following:

$$TD = \sum_{t=1}^{N} D^t \frac{A}{N} (0.48) \tag{10}$$

or

$$TD = 0.48 \frac{A}{N} \sum_{t=1}^{N} D^t \tag{11}$$

4.1.4 ATCS LCC Model (Tax Effects Included)

When the LCC equation (Equation 5) is modified to include the effects of investment credit (Equation 6) and depreciation deduction (Equation 11), the general form of the life-cycle-cost model for the automated terminal management control system becomes

$$LCC = A(1-C) + \sum_{t=1}^{L} D^t (O_t + M_t) - 0.48 \frac{A}{N} \sum_{t=1}^{N} D^t \tag{12}$$

where all terms are as previously defined.

If the depreciation period is equivalent to the system life (N=L), Equation 12 simplifies to the following form:

$$LCC = A(1-C) + \sum_{t=1}^{L} D^t \left(O_t + M_t - 0.48 \frac{A}{L}\right) \tag{13}$$

4.2 BENEFIT ASSESSMENT

Section 4.1 described the development of a life-cycle-cost model for an automated terminal management control system (Equations 5 and 12). The benefits accrued from the implementation of such a system will now be addressed so that the cost-benefit relationships can be evaluated.

The assessment of the benefits to be realized by installing and employing a new system is a formidable task. The analyst is concerned about whether his results will be credible when compared with the system costs, which are normally much more precise. Further, he must determine how to account for highly intangible benefits that may not be capable of quantification but nonetheless can have considerable impact on the decision whether to buy the system.

Two immediately apparent areas in which an automated terminal management control system could be expected to show improvement over a manual system are (1) reduced information-processing time and (2) reduced errors in the information. These improvements can manifest themselves in many types of benefits -- some quantitative (measurable in terms of cost savings) and some qualitative. The following subsections describe both the quantitative and the qualitative benefits identified during the analysis.

4.2.1 Quantitative Benefits

To provide a basis for comparing benefits with costs, this analysis expresses the benefits in terms of cost savings to the terminal operator. The benefits could be expressed in other terms (e.g., increased throughput), but the comparative analysis would be far less straightforward. Accordingly, for the analyses described herein, a terminal is assumed to have a constant throughput, and benefits are assumed to result in savings in the cost of providing that throughput.

During the survey activities discussed in Chapter Two, marine terminal industry personnel were queried with respect to cost savings associated with the automation of data handling and control. Those associated with terminals currently having some form of automation were asked to identify areas in which savings resulted from automation. Persons associated with terminals where data are handled manually were queried about areas in which they might expect savings to be realized if they installed an automated system.

The results of these queries were combined with information from published reports on similar efforts and from first-hand observation of terminal operations to identify a basic set of benefit areas that could be expressed in terms of direct cost savings for the terminal operator. The following three areas were identified:

- Reduction in data-handling work force
- Increase in productivity of yard forces
- Reduction in container rehandling due to data errors

The following sections address these areas and present the benefit-assessment model.

4.2.1.1 Reduction in Data-Handling Work Force

The principal terminal areas where personnel are involved in the acquisition, handling, and use of operational data are the gate, the receiving and delivery offices, the central files and the yard control tower or office. The extent to which the work force could be reduced, or job functions combined, as a result of data automation is highly dependent on individual terminal characteristics, operating procedures, labor agreements, and other factors. It was generally agreed, however, that cost savings would be realized at one or more of these areas for any terminal that installed an automated terminal control system.

The general expression for cost savings attributed to reductions in the work force involved in handling data is

$$SRWF = H_p \times [(S \times W_s) + (C \times W_c)] \tag{14}$$

where

SRWF = Annual savings due to reduction in work force (dollars)

H_p = Total hours worked per year per position eliminated

S = Number of supervisory positions eliminated

W_s = Hourly wage for supervisory personnel (dollars)

C = Number of clerical positions eliminated

W_c = Hourly wage for clerical personnel (dollars)

In Equation 14 it is assumed that both clerical and supervisory personnel work the same number of hours per year; the equation could easily be modified to accommodate another assumption.

4.2.1.2 Increase in Productivity of Yard Forces

Because of the improved timeliness and accuracy of information regarding containers and container moves associated with an automated system, an improvement in the efficiency or productivity of container-handling forces can be anticipated. This increased productivity might be manifested in several ways, including increased throughput, elimination of overtime, reduction in number of shifts worked, and reduction in number of vehicles required.

Since constant throughput has been assumed for these analyses, it is clear that an improvement in productivity would eventually be reflected in a reduction in the cost of yard operations. For convenience of analysis, this reduction has been expressed in terms of the cost of operating and

maintaining yard container-handling vehicles, including drivers, as follows:

$$SYVC = H_V \times V \times P \times (R_V + M_V) \tag{15}$$

where

- SYVC = Annual savings in yard vehicle operating cost (dollars)
- H_V = Total hours worked per year per yard vehicle
- V = Number of yard vehicles to handle specified throughput in a terminal where data are handled manually
- P = Factor to account for increased productivity (percent)
- R_V = Cost per hour of operating a yard vehicle, including driver (dollars)
- M_V = Cost per operating hour of maintaining a yard vehicle (dollars)

4.2.1.3 Reduction in Container Rehandling Due to Data Errors

There is considerable variation in the estimates of the extent to which containers are handled a number of times on a terminal for no reason other than the incorrectness of information on container number, disposition, storage location, stowage assignment, etc. It is generally agreed, however, that such multiple moves do occur, and that their frequency at a terminal where information is entered and handled manually is greater than at one where a computer provides more consistent, accurate, and timely information.

The following expression was derived to compute the cost value of a reduction in container rehandling because of a reduction in information errors:

$$SCHC = T \times R_V \times Q \times E \tag{16}$$

where

- SCHC = Annual savings in container handling costs (dollars)
- T = Cycle time to move a container to and from storage (hours)
- R_V = Cost per hour of operating a yard vehicle, including driver (dollars)
- Q = Annual throughput in number of containers
- E = Factor to account for reduced error rate (percent)

4.2.1.4 Benefit-Assessment Model

The general form of the benefit-assessment model, including a discount factor so that the discounted cash flows can be compared with those for life-cycle cost, is as follows:

$$LCB = \sum_{t=1}^{L} D^t \, (SRWF + SYVC + SCHC)_t \tag{17}$$

where LCB = Benefits accrued over the life cycle (dollars), and other terms are as previously defined.

Upon substitution from Equations 14 through 16, Equation 17 becomes

$$LCB = \sum_{t=1}^{L} D^t \left\{ H_p \times [(S \times W_S) + (C \times W_C)] + H_V \times V \times P \times (R_V + M_V) + T \times R_V \times Q \times E \right\} \tag{18}$$

The results of exercising this model, using representative marine terminal data, are discussed in Section 4.3.

4.2.2 Qualitative Benefits

The quantitative benefits addressed in Section 4.2.1 are certainly not all-inclusive. It was intended to include those benefits which (1) readily lent themselves to quantification in terms of cost savings, (2) were easily understood in terms of physical effects on the terminal, and (3) could easily be estimated without resorting to a large-scale data-collection effort. Furthermore, it is recognized that there are many types of benefits that cannot be quantified but can have great influence on a terminal operator's decision to automate his terminal control process. The purpose of this section is to address some of these "qualitative" benefit types.

The following subsections describe qualitative benefits of an automated system in the following areas:

- Improved Operations Planning
- Improved Reporting
- Improved Utilization of Terminal Resources
- Reduced Gate Queues
- Increased Throughput
- Improved Business Information

4.2.2.1 Improved Operations Planning

Since an automated system can be expected to provide more accurate and timely information than a manual one, a key qualitative benefit to the terminal operator is improved ability to plan many aspects of his operation. He can better plan the ordering of work gangs, the assignment of work responsibilities, and the allocation of container storage space; and he can make many other daily and hourly decisions on a more informed basis because of the up-to-date inventory and statistical information to which he has immediate access.

4.2.2.2 Improved Reporting

In addition to having improved plannir[illegible] ability, the terminal operator is better equipped to provide routine reports and tabulations to shiplines, agents, and others in his customer communit[illegible] By pushing a button, he can create an entire library of reports that c[illegible] take many man-hours, or even man-days, to create manually. He can also respond quickly to inquiries by shippers, carriers, or customers who want immediate information on the location and status of a container, the number of containers received on a particular booking, the number of empty containers available on hand, and a myriad of other subjects.

4.2.2.3 Improved Utilization of Terminal Resources

The automation of the control process will not only speed up the flow of data; it will also allow better utilization of terminal resources (personnel, vehicles, space, etc.). Because container movements can be planned in advance and executed in a logical sequence, yard congestion can be reduced. There will be accompanying reductions in the time necessary to load and discharge a ship, with a resultant decrease in ship turnaround time. The value of time in port is significant to the steamship operator; reduction of this time could well lead to more business for the terminal.

4.2.2.4 Shortened Gate Queues

The ability to handle information more rapidly at the gate should significantly reduce the time needed to process receipts and deliveries. As a result, truck queues can be shortened and driver waiting time reduced. This service improvement can also favorably affect customer relations and attract additional business.

4.2.2.5 Increased Throughput

As new business is attracted, it is necessary to develop the ability to handle it, that is, the ability to increase terminal throughput. As explained in Section 4.2.1, the analyses described in this chapter were based on the assumption of a constant throughput. Cost savings were postulated on providing that level of throughput more efficiently (fewer people, lower operating cost, fewer vehicles, etc.). It was important that the analysis take this form so that benefits could be compared directly with costs. It can also be argued, however, that if a fixed throughput can be

maintained at reduced cost, then increased throughput should be possible for the original extenditure. Viewed in this light, any savings computed in this chapter can be interpreted to provide a potential for increased throughput, assuming that other necessary provisions can be made to handle the throughput (space, facilities, etc.).

4.2.2.6 Improved Business Information

In addition to the benefits discussed thus far, all of which have been operationally oriented, a number of business-oriented benefits can accrue from an automated control system. For example, the system can provide the information necessary to execute billings for services, demurrage, etc., in a timely manner whether the billing function is incorporated directly into the system or not. Historical and statistical information derived from such a system can be used for planning expansion or adjustment of terminal facilities and other resources. Loss and damage claims should be reduced by timely and accurate information, not only on the location and status of containers in the inventory but also on the location and movements of transient personnel at the terminal.

4.2.3 Summary

In summary, the marine terminal is a service facility. Any innovative approach to improving that service will be attractive to the terminal operator. The extent to which his decision on investing in such innovation is influenced by quantitative versus qualitative factors will vary with individual terminals and operators. The purpose of the material in this chapter is to provide to the operator the kinds of analyses and discussions that will permit him to make an informed decision for his particular situation.

4.3 PRELIMINARY COST-BENEFIT ANALYSES

The models presented in Sections 4.1 and 4.2 were exercised, with representative marine terminal values being used for the variables, to compute a set of life-cycle costs and benefits believed to encompass a broad range of cases applicable to most public marine terminals.

The primary sources of information for defining the hypothetical terminals and selecting parameter values to be used in these analyses were a number of key documents*, as well as extensive discussions and observations at terminals visited during the survey.

**Methodology for Estimating the Capacity of Marine Terminals*, Volume I, prepared by Manalytics, Inc., for the Maritime Administration and the Northern California Ports and Terminals Bureau, Inc.

Port Planning, Design and Construction Manual, American Association of Port Authorities.

Communications in the Marine Terminal, Society of Naval Architects and Marine Engineers.

It should be pointed out that while every attempt was made to use values representative of marine terminal experience, the ranges of the results obtained are more instructive than the individual results themselves. If the extreme maximum and minimum values are indeed representative of boundary values for the majority of terminals, then an individual terminal can reasonably be expected to fall within the computed ranges.

4.3.1 Baseline Marine Terminal Configurations

As a baseline for analysis, three hypothetical marine terminal configurations were defined and designated Terminals A, B, and C. Table 4-1 shows the baseline characteristics for each of these three generic terminals. It should be noted that the throughput (column 2) is held constant for each terminal in all subsequent analyses, as are the number of export and import gate lanes (columns 3 and 4, respectively).

4.3.2 Values and Assumptions Used for Model Exercises

The following subsections present the values used in computing the life-cycle-cost and benefit results addressed in subsequent sections of this chapter.

4.3.2.1 Life-Cycle Cost

To compute life-cycle costs of automated terminal management control systems for each of the marine terminals, the following general assumptions were made:

- A computer would be installed at a central point and would have sufficient capacity to accommodate current throughput with potential for moderate growth.
- "Intelligent" data terminals (as described in Chapter Three) would be installed as follows: one at each gate lane, one at the control tower or office, and one at the computer location (for management use and report preparation).
- Maintenance of the system would be supplied under contract at 10 percent of the purchase price per year (constant).
- Operating costs (for power, paper supplies, magnetic tapes, etc.) would total 7.5 percent of the purchase price per year (constant).
- System purchase cost would be depreciated over seven years (maximum allowed by IRS for computer systems), permitting a 10 percent investment credit. (Note: Computations were made for five-year depreciation, and the effect was insignificant.)
- The life cycle is 10 years.

Discussions with computer manufacturers and with operators of marine terminals that now have computers led to the conclusion that reasonable estimates for the cost of such systems would be $100,000 for Terminal A, $200,000 for

Table 4-1. BASELINE MARINE TERMINAL CHARACTERISTICS

Marine Terminal	Throughput (Containers per Year)	Number of Gate Lanes		Number of Personnel Handling Data (Manual Data System)							
				Gate*		Receiving Delivery Office		File Center		Yard Control	
		Export	Import	Supervisors	Clerks	Supervisors	Clerks	Supervisors	Clerks	Supervisors	Clerks
A	50,000	4	2	0	16	1	2	1	1	0	2
B	100,000	6	3	0	24	1	4	1	2	1	3
C	150,000	8	4	0	32	1	6	1	3	1	4

*Assume 3 persons per export lane (booth checker, gate man, and interchange writer); assume 2 persons per import lane (gate man and interchange writer).

Terminal B, and $270,000 for Terminal C. To each of these must be added the cost of data terminal installations (estimated at $6,000 each for intelligent terminals with high-speed printers) to arrive at a total cost for each marine terminal.

The data used for computing life-cycle costs, based on the assumptions described above, are summarized in Table 4-2. These data are believed to represent an upper range of expected costs, yielding conservatively high values of LCC.

Table 4-2. LIFE-CYCLE-COST DATA

Variable	Data, by Terminal		
	A	B	C
Acquisition Cost (A), Dollars	148,000	266,000	354,000
Investment Credit Factor (C)	0.1	0.1	0.1
Life Cycle (L), Years	10	10	10
Discount Factor (D)	0.90909	0.90909	0.90909
Operating Cost (O), Dollars	11,100	19,950	26,550
Maintenance Cost (M), Dollars	14,800	26,600	35,400
Depreciation Period (N), Years	7	7	7

4.3.2.2 Benefit Assessment

Because of the imprecise nature of the data required to compute system benefits, it was decided to compute three sets of benefits for each terminal configuration: a minimum case, a maximum case, and a case representing reasonable intermediate values of the variables. The values used for each of these cases are described in the following paragraphs and summarized in Table 4-3.

4.3.2.2.1 Minimum Case

Data values for the minimum case were selected to represent an extremely conservative estimate of anticipated benefits.

Data-Handling Work Force. For the minimum case, it was assumed that no reduction would occur in personnel positions at the gates. In the receiving and delivery office, reductions of one, two, and three clerical positions were assumed, respectively, for Terminals A, B, and C. In the file center, it was assumed that only a supervisory position would remain

Variable	Terminal A Data			Terminal B Data			Terminal C Data		
	Min.	Max.	Intermed.	Min.	Max.	Intermed.	Min.	Max.	Intermed.
Supervisory Positions Reduced (S)	0	1	0	0	1	0	0	1	0
Clerical Positions Reduced (C)	2	8	6	5	15	10	7	21	13
Yard Vehicles (V)	← 20 →			← 40 →			← 60 →		
Productivity Improvement (P)	0	.25	.10	0	.25	.10	0	.25	.10
Throughput (Q)	← 50,000 →			← 100,000 →			← 150,000 →		
Error Reduction (E)	.01	.05	.03	.01	.05	.03	.01	.05	.03

Table 4-3. BENEFIT-ASSESSMENT DATA

Constant Values for All Cases, All Terminals:

Life-Cycle Period (Years)	(L)	= 10
Discount Factor	(D)	= 0.90909
Hours Worked per Year (Personnel)	(H_P)	= 2500*
Hourly Salary for Supervisors (Dollars)	(W_S)	= 15 (loaded)
Hourly Salary for Clerks (Dollars)	(W_C)	= 10 (loaded)
Hours Worked per Year (Vehicles)	(H_V)	= 2500*
Operating Cost per Vehicle-Hour (Dollars)	(R_V)	= 35
Maintenance Cost per Vehicle-Hour (Dollars)	(M_V)	= 3.50
Cycle Time per Container Move (Hours)	(T)	= 0.1

*A six-day work week was assumed.

to provide a management interface with the computer; as a result, Terminals A, B, and C eliminated one, two, and three clerical positions, respectively. At the control tower or office, Terminal A eliminated no positions, while Terminals B and C each eliminated one clerical position. In summary, no supervisory positions were eliminated; clerical positions eliminated were two at Terminal A, five at Terminal B, and seven at Terminal C.

Yard Forces Productivity and Container Rehandling. For all three terminals, it was assumed that no productivity improvement was obtained and that handling errors representing one percent of container throughput were eliminated.

4.3.2.2.2 Maximum Case

Although the maximum parameter values selected are considerably greater than the minimum-case values, they do not appear to represent an unreasonably high upper bound. No real-life data were obtained for personnel position reductions; however, even if the number of reductions appears to be high, the relatively low values used for loaded wages tend to moderate the effect on benefits, thereby keeping the estimates somewhat conservative. Further, improved gate service time could result in the elimination of complete gate lanes and even further cuts in personnel positions. As for the values assumed for productivity improvement and handling-error reduction, estimates obtained from terminal operators ranged up to twice the estimates used for this maximum case.

Data-Handling Work Force. In the maximum case, it was assumed that one clerical position (e.g., booth checker) could be eliminated at each export gate lane, resulting in the elimination of four clerical positions at Terminal A, six at Terminal B, and eight at Terminal C. Because of the potential for direct interaction of gate personnel with the computer, it is assumed that the receiving and delivery office positions are all eliminated and the functions transferred. As a result, one supervisory position is eliminated at each terminal, plus two clerical positions at Terminal A, four at Terminal B, and six at Terminal C. In the file center, it was assumed that only a supervisory position would remain (as in the minimum case) to act as a management interface with the computer; thus clerical positions eliminated were one at Terminal A, two at Terminal B, and three at Terminal C. At the control tower or office, clerical positions eliminated at Terminals A, B, and C were one, three, and four, respectively. In summary, one supervisory position was eliminated at each terminal, while clerical positions eliminated were 8, 15, and 21 at Terminals A, B, and C, respectively.

Yard Forces Productivity and Container Rehandling. For all three terminals, it was assumed that productivity improvement was 25 percent and that the reduction in handling errors represented 5 percent of throughput.

4.3.2.2.3 Intermediate Case

Values for the intermediate case were chosen somewhat arbitrarily to provide a set of cost-benefit results lying somewhere between the boundary cases. Personnel-position reductions were set approximately halfway between the extreme values. Productivity improvement was set at 10 percent; and reduction in handling errors was set at 3 percent of throughput.

If the minimum and maximum cases appear to represent reasonable bounds, the intermediate case can be interpreted as a reasonably likely estimate for a representative set of marine terminals.

4.3.3 Preliminary Cost-Benefit Analysis

The results of exercising the cost model represented by Equations 5 and 12 and the benefit model represented by Equation 18, using the data values in Tables 4-2 and 4-3, are shown in Table 4-4. Figure 4-1 is a bar graph of the values shown in Table 4-4.

Table 4-4 shows that the system life-cycle costs for Terminal A range from $307,000 to $243,000 depending on whether tax effects are included. Life-cycle benefits for the same terminal range from $318,000 to $4,470,000. For Terminal B, life-cycle costs range from $552,000 to $437,000, while benefits range from $790,000 to $8,556,000. Life-cycle costs for Terminal C range from $735,000 to $581,000, while benefits range from $1,107,000 to $12,489,000. It is significant that, for all three terminals, even the minimum-case benefits exceed the life-cycle cost of a system expected to provide those benefits.

The relative magnitudes of costs and benefits are shown quite clearly in Figure 4-1. In addition, Figure 4-1 illustrates well the relative contributions of the various benefit categories. Productivity- and personnel-related benefits account for virtually all of the quantified benefits, while error reduction makes relatively little contribution to the total. Figure 4-1 also illustrates the relative insignificance of tax effects in comparison with anticipated benefits.

Figures 4-2, 4-3, and 4-4 present the cumulative annual discounted costs and benefits for Terminals A, B, and C, respectively, effectively showing the spread of the curves representing the three cases of benefits for each terminal. When plotted on the same scale, however, the costs are difficult to discern. Only for the minimum-benefit cases do costs ever exceed benefits; the points at which they cross are not easy to identify on this scale.

The cross-over points at which benefits break even with costs are better seen in Figures 4-5 through 4-7, presenting cash-flow curves for the hypothetical terminals. These curves, obtained by summing algebraically the cash flows for costs and benefits for each year, show the point at which cash flow goes from positive (excess cost) to negative (excess benefit). As can be seen in the figures, for the maximum- and intermediate-benefit cases, all terminals break even within the first year. For the minimum-benefit cases, Terminal A breaks even in the ninth year, Terminal B in approximately four years, and Terminal C in the third year.

These same data are then used to compute the return on investment (ROI) for the minimum-benefits case* for each of the terminals; these results are also shown in Figures 4-5 through 4-7. For this analysis, the ROI is defined as the rate of return that will make the undiscounted benefits equal

*The ROI for cases other than the minimum were not computed, because these cases all broke even before the end of the first year, producing an extremely high value for ROI; such a value cannot be realistically interpreted in financial terms.

(text continued on page 4-26)

Table 4-4. LIFE-CYCLE COSTS AND BENEFITS; CUMULATIVE, DISCOUNTED OVER 10 YEARS

Terminal and Case	Life-Cycle Costs (Dollars)		Life-Cycle Benefits (Dollars)			
	Before Taxes	After Taxes	Productivity	Personnel	Errors	Total
Terminal A	307,000	243,000				
Minimum Case			0	307,000	11,000	318,000
Intermediate Case			1,183,000	922,000	32,000	2,137,000
Maximum Case			2,957,000	1,459,000	54,000	4,470,000
Terminal B	552,000	437,000				
Minimum Case			0	768,000	22,000	790,000
Intermediate Case			2,366,000	1,536,000	64,000	3,966,000
Maximum Case			5,914,000	2,535,000	107,000	8,556,000
Terminal C	735,000	581,000				
Minimum Case			0	1,075,000	32,000	1,107,000
Intermediate Case			3,548,000	1,997,000	97,000	5,642,000
Maximum Case			8,871,000	3,457,000	161,000	12,489,000

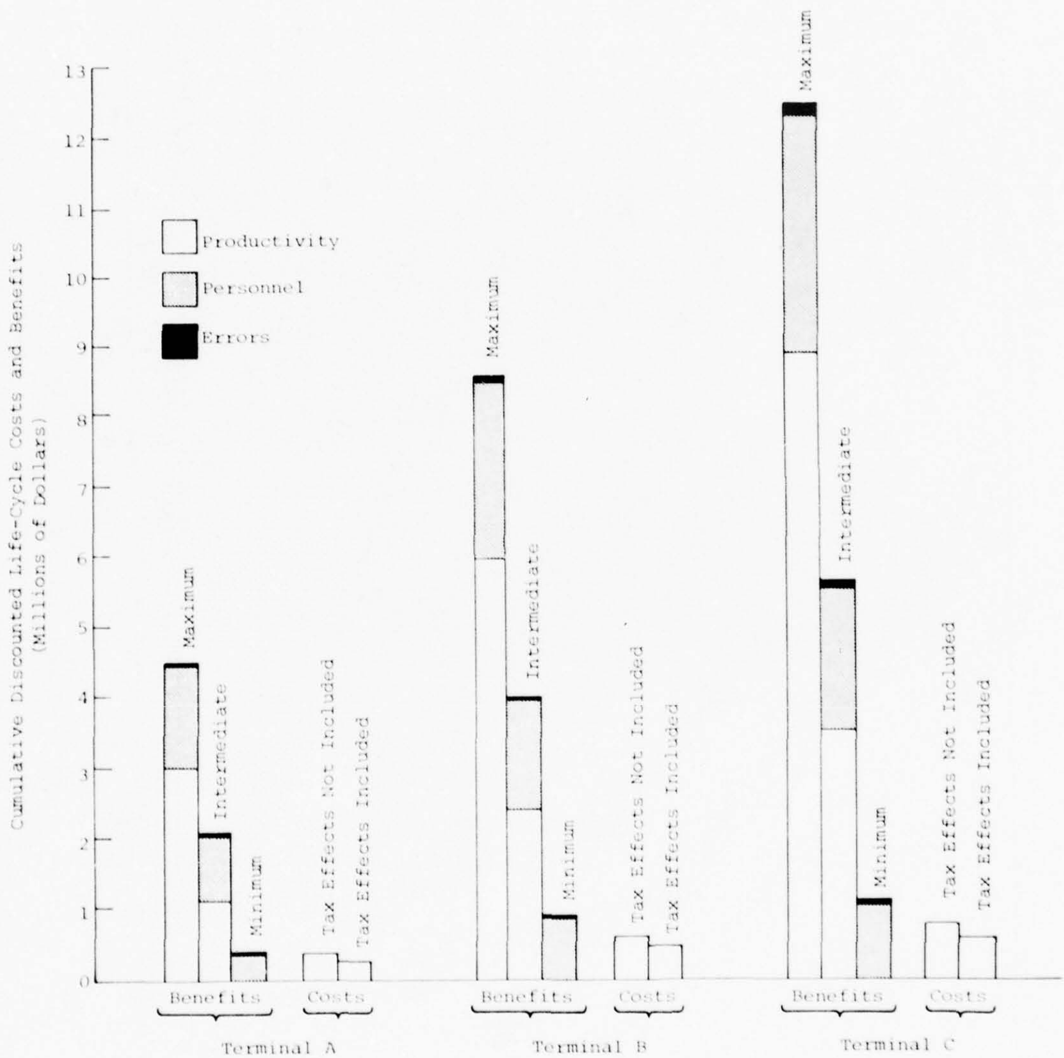

Figure 4-1. LIFE-CYCLE COSTS AND BENEFITS FOR THREE HYPOTHETICAL MARINE TERMINALS

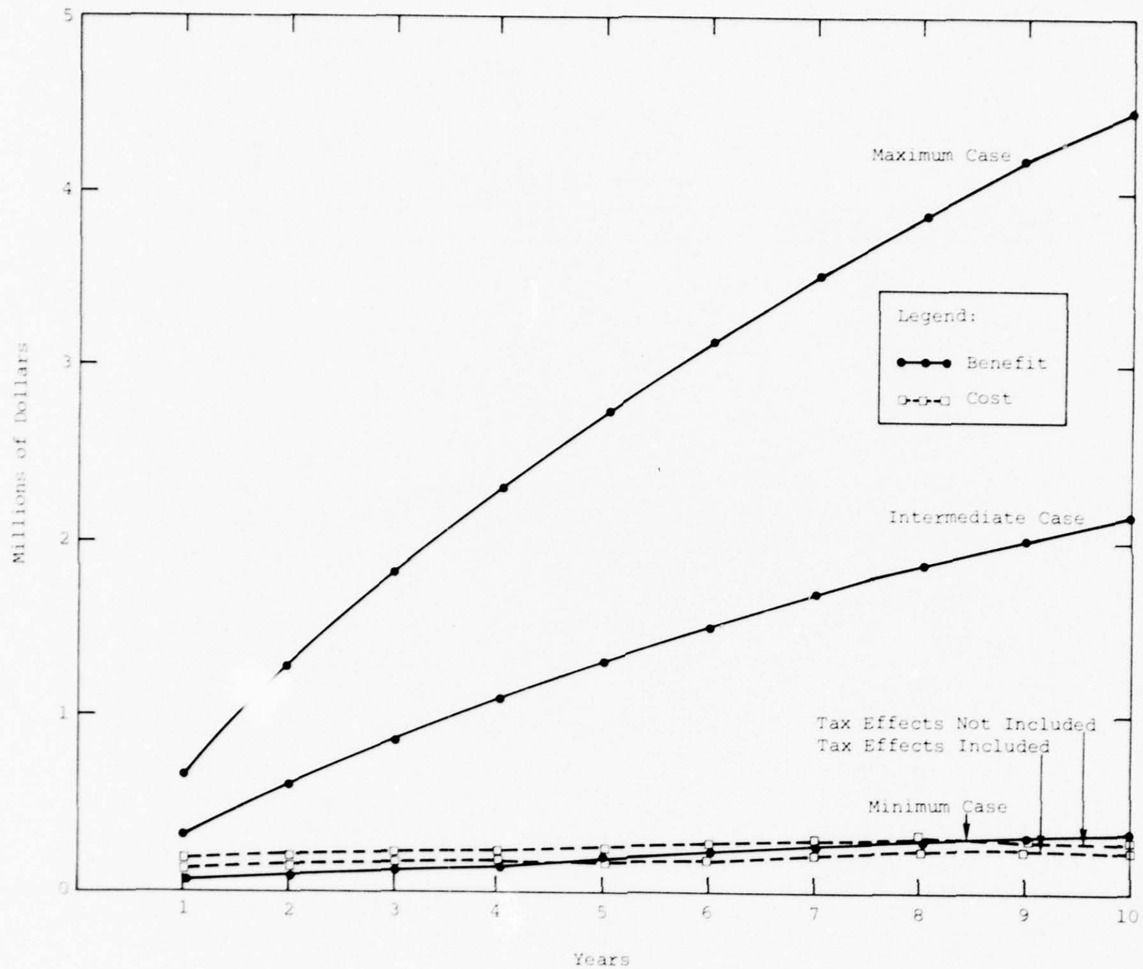

Figure 4-2. CUMULATIVE ANNUAL DISCOUNTED COSTS AND BENEFITS FOR TERMINAL A

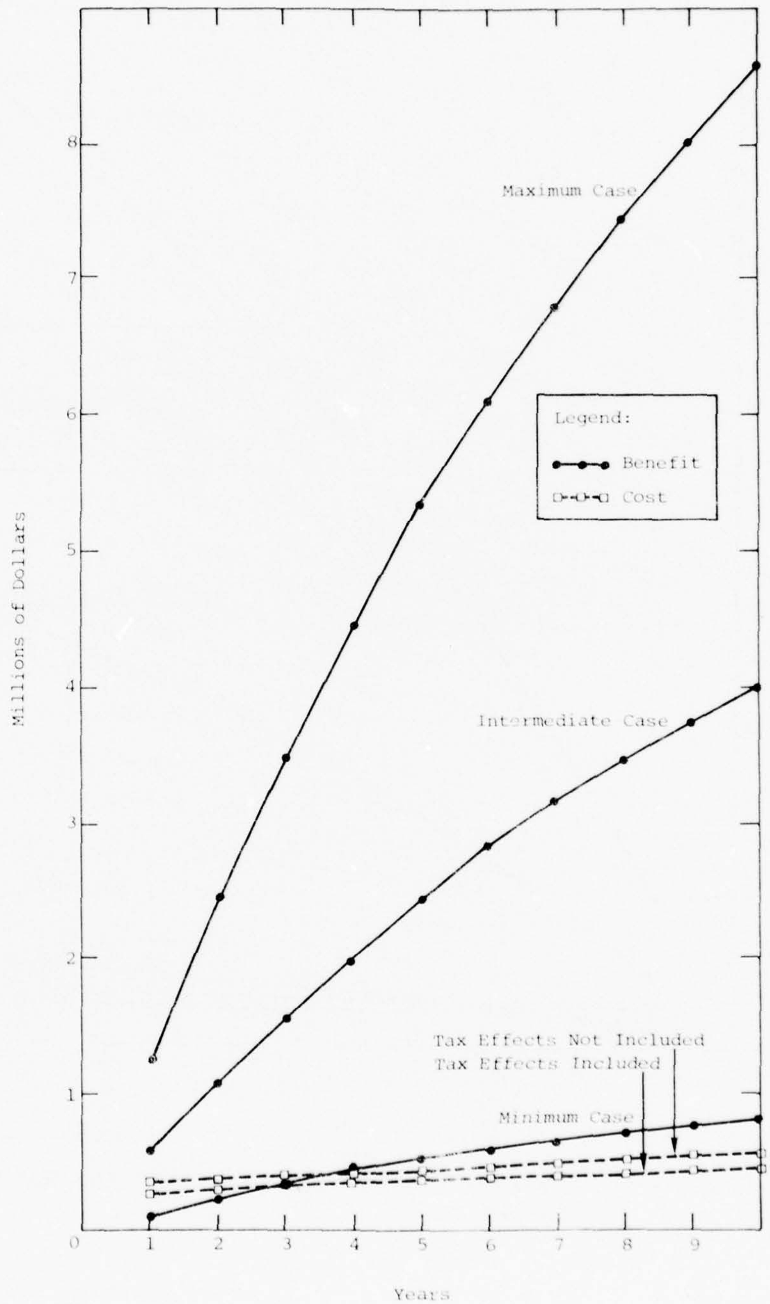

Figure 4-3. CUMULATIVE ANNUAL DISCOUNTED COSTS AND BENEFITS FOR TERMINAL B

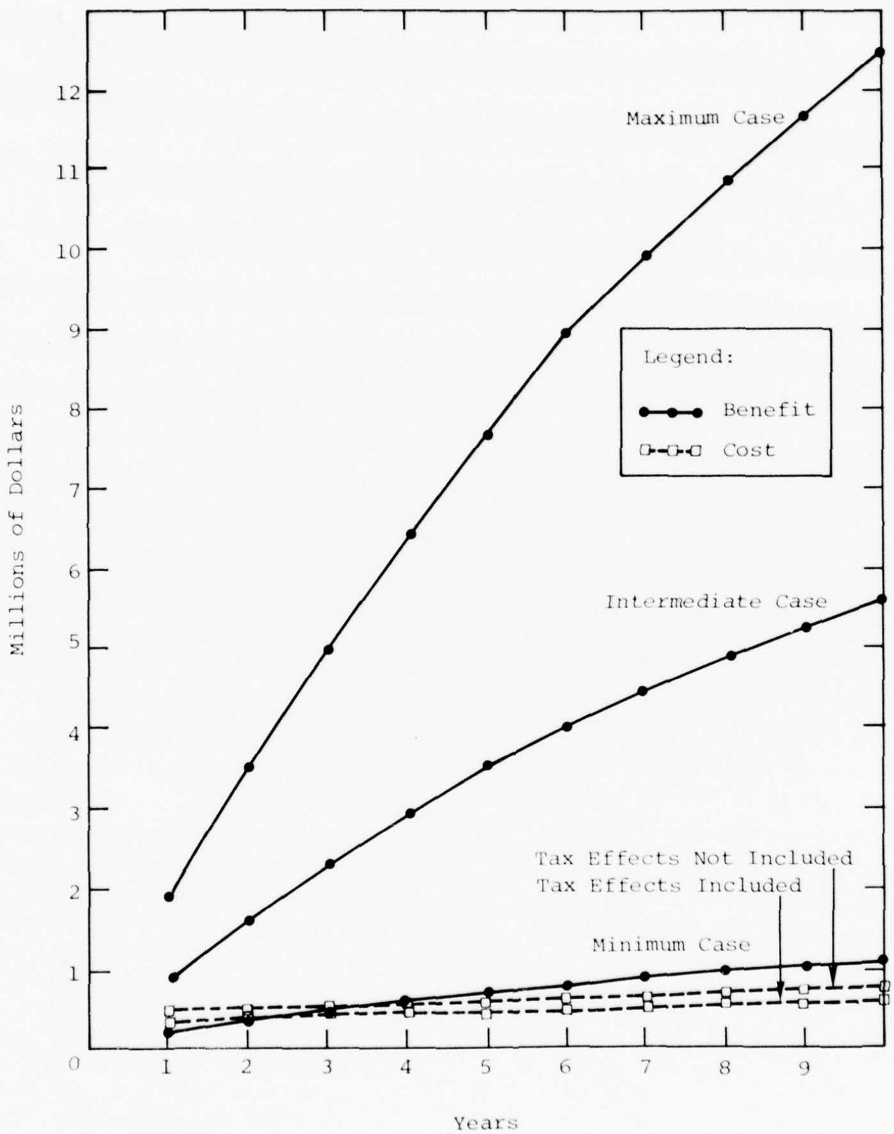

Figure 4-4. CUMULATIVE ANNUAL DISCOUNTED COSTS AND BENEFITS FOR TERMINAL C

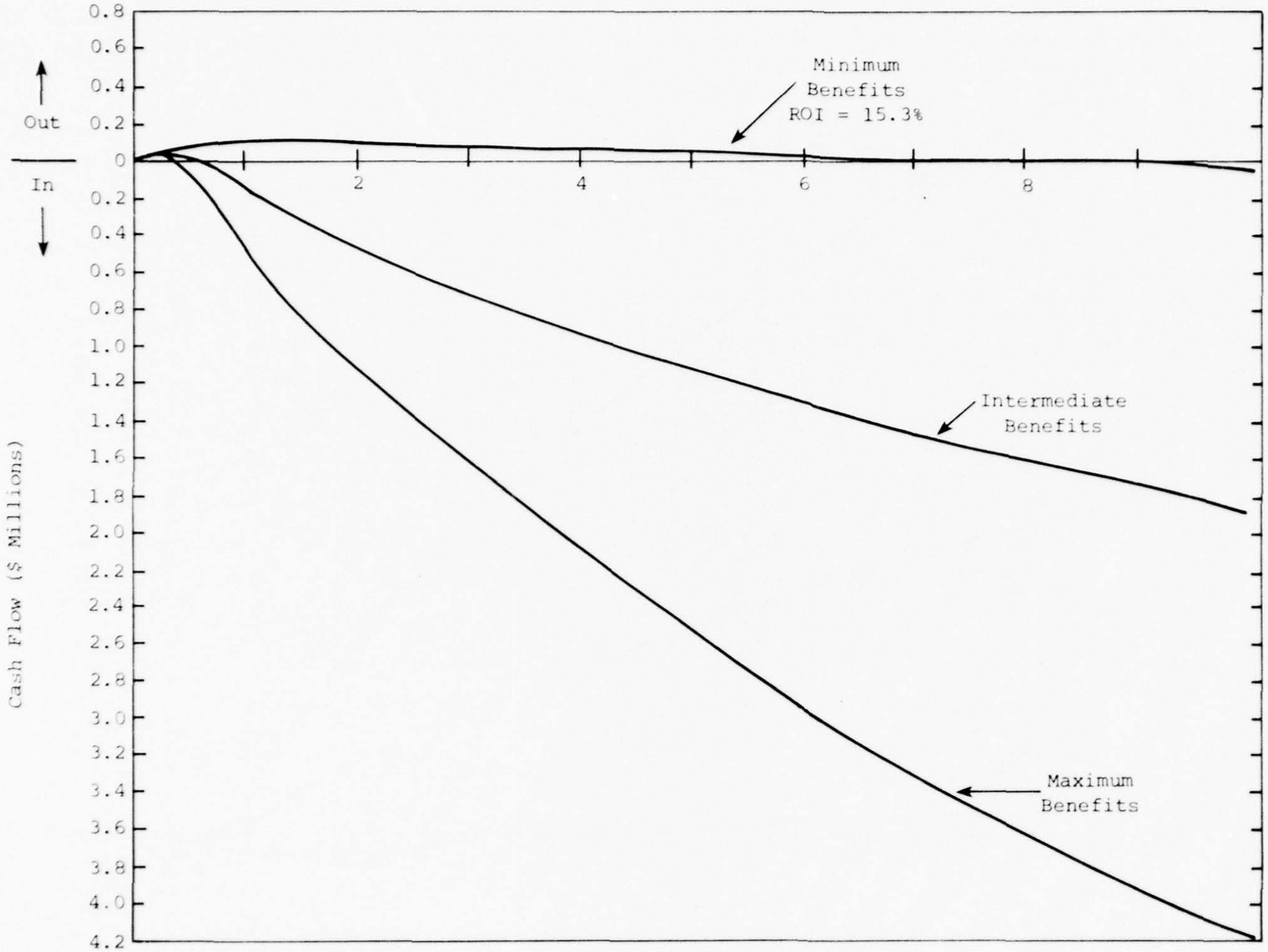

Figure 4-5. DISCOUNTED CASH FLOW FOR TERMINAL A

analysis take this form so that benefits could be compared directly with
costs. It can also be argued, however, that if a fixed throughput can be

4-10

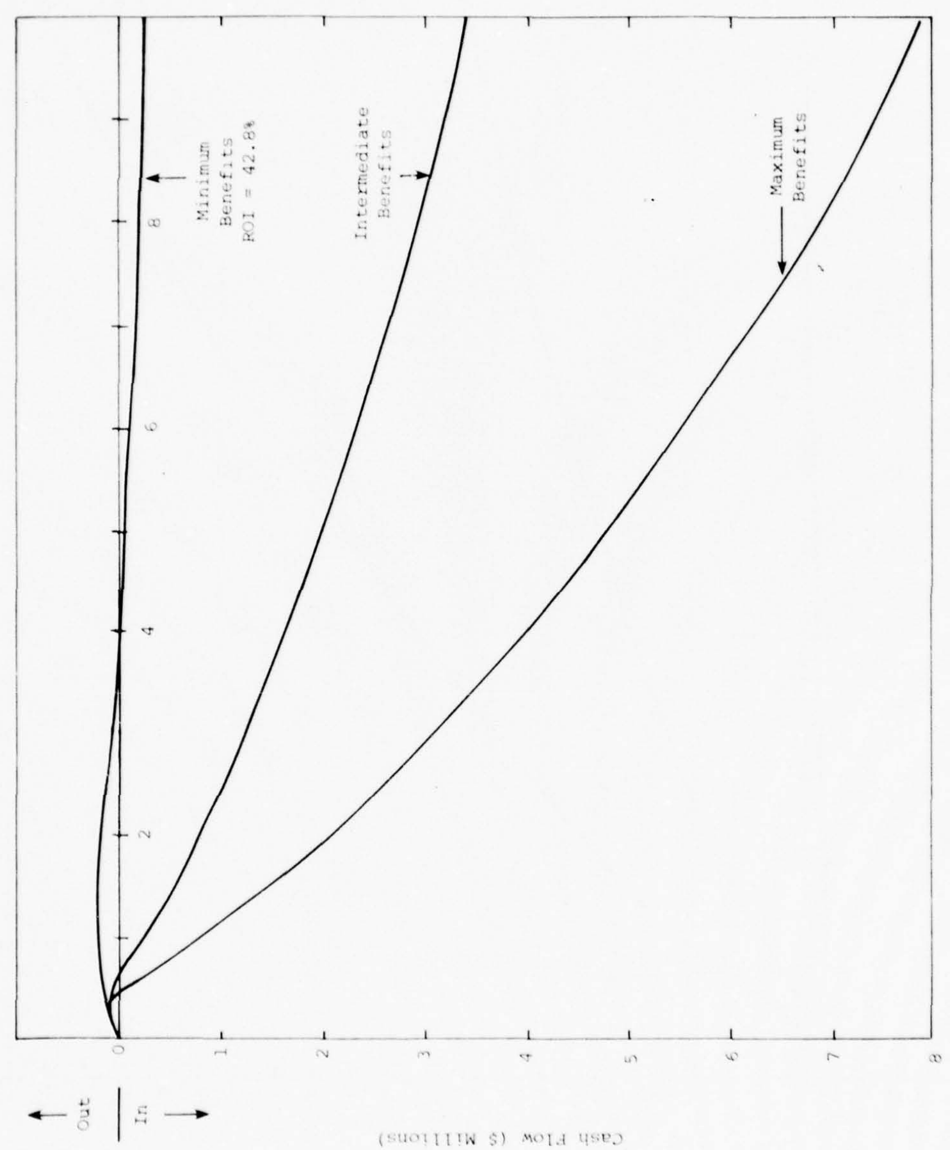

Figure 4-6. DISCOUNTED CASH FLOW FOR TERMINAL B

Communications in the Marine Terminal, Society of Naval Architects and Marine Engineers.

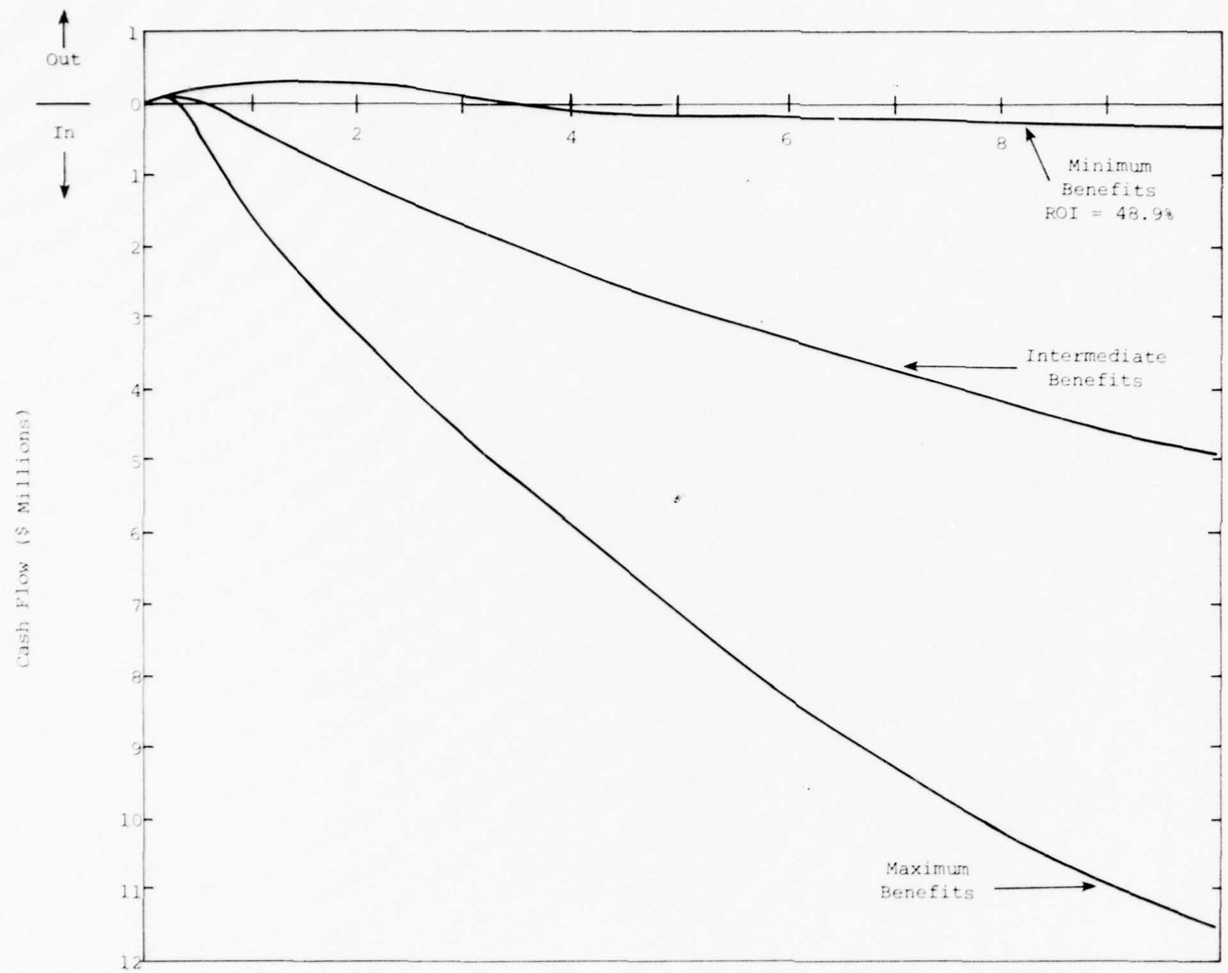

Figure 4-7. DISCOUNTED CASH FLOW FOR TERMINAL C

to the undiscounted costs over the life cycle. It can also be thought of as the interest rate at which the present value of system costs would have to be invested to yield income equivalent to the present value of system benefits. As such, it provides a good basis for comparing opportunities for investment.

As Figures 4-5 through 4-7 show, an assumption of minimum-case benefits provides an ROI of 15.3 percent for Terminal A, 42.8 percent for Terminal B, and 48.9 percent for Terminal C. For any given terminal, actual data would have to be used to derive ROI values before investment opportunities could be evaluated. For the hypothetical data used, however, automated systems would appear to be attractive investments.

4.4 MAJOR CONCLUSIONS FROM ANALYSES

The analyses presented in this chapter show that an automated marine terminal management control system should more than pay for itself during its useful life. For extremely conservative (minimum case) assumptions regarding system costs and potential savings in terminal operating costs, the analyses show a break-even ranging from 3 to 9 years and a rate of return on investment ranging from 15 percent to almost 49 percent, depending on container throughput capacity. These results were computed for hypothetical marine terminals, but the terminal characteristics used are believed to be representative of a broad range of actual terminals.

To evaluate the cost-benefit relationships for a specific marine terminal, the models presented in this chapter must be exercised by using parameter values applicable to that terminal. It would be surprising if such values were more conservative than the ones used for calculating minimum-case results in this chapter; accordingly, even more favorable cost-benefit and ROI results would be anticipated.

When the qualitative benefits of an automated system are considered in addition to the quantitative benefits computed, such a system represents a highly attractive opportunity to improve overall terminal operations and enhance the terminal's competitive position.

CHAPTER FIVE

EXTENSION OF THE AUTOMATED TERMINAL CONTROL SYSTEM BEYOND THE MARINE TERMINAL

The principal purpose of the activities performed during this project was to expedite and make more efficient the handling of containers in a marine terminal. Accordingly, emphasis was placed on finding more cost-effective ways of moving containers from gate to ship and from ship to gate. The requirements for a system to control the movement and storage of containers at the marine terminal were defined, and concepts for automating various elements of the control process were identified. Finally, a methodology was developed and applied to analyze the trade-offs between the cost of an automated system and the benefits it might provide to the terminal operation. The results of all these activities have been reported in preceding chapters of this report.

In this chapter, an additional issue is addressed: the extension of the concept of an automated terminal management control system beyond the boundaries of the marine terminal itself. Two types of extension are examined:

- The exchange of information on containers and container status with parties outside the terminal
- The sharing of terminal control computer resources by multiple users on either a geographic or a corporate basis

These areas are treated in the following sections of this chapter. As will be seen, the two areas are not totally independent; some aspects of the concept of extension are common to both.

5.1 EXTENSION OF THE USE OF INFORMATION

The information that is important and essential to a marine terminal for transferring cargo from one shipment mode to another (land to sea or sea to land) is important to many other parties as well. Shippers, consignees, brokers, agents, forwarders, and carriers (both on land and water), as well as various agencies within the port, all have a common interest with the terminal operator in the efficient and economical movement of cargo from origin to destination. Further, each of these parties has some role in the origination or ultimate disposition of some of the information used by the terminal operator.

positions were assumed, respectively, for Terminals A, B, and C. In the file center, it was assumed that only a supervisory position would remain

The existence of this common interest, together with the mutual need for information, provides strong argument for improving the means of exchanging data among the various interested parties. An automated management control system at a marine terminal is an important vehicle for transmitting data electronically from the terminal to other parties and, conversely, receiving such data from other parties.

Four areas of data exchange to and from the marine terminal are discussed in the following subsections:

- Exchange with carriers
- Exchange with shippers
- Exchange with other port agencies
- Nationwide exchange for container tracking

In all these areas, there are important benefits to be gained both by the terminal and by the party with whom the exchange takes place.

5.1.1 Data Exchange with Carriers

The marine terminal functions as the focal point of intermodal transfer between land and water transportation of cargo and is thus an important focal point for information on intermodal shipments.

Advance notification of export goods en route by rail or truck can provide useful information to the terminal operator for planning utilization of his resources. This information can also be forwarded to the shiplines for their use in planning vessel call schedules, stowage plans, etc.

On the import side, advance manifest and unloading information can help the terminal operator plan for the ship's arrival and service it more efficiently. The terminal can also give advance notice to the land carriers so that they can be prepared to have the necessary trucks, chassis, and railcars available to reduce the on-terminal storage time of import containers.

In both cases, export and import, the advance information on containers en route can be the starting point for building files on those containers that will greatly expedite their processing on arrival at the marine terminal.

5.1.2 Data Exchange with Shippers

The benefits associated with direct electronic data exchange with shippers are greater for the terminal than for the shipper. Advance information from a shipper on cargo loaded in an export container is another source of data upon which to build a file to expedite gate processing on arrival. Receipt of the data electronically eliminates the need for a clerk to enter these data into the files.

supervisory positions were eliminated; clerical positions eliminated were two at Terminal A, five at Terminal B, and seven at Terminal C.

Benefits to be gained by the shippers are primarily in the area of inquiries about the location and status of particular container shipments. With proper security precautions, a shipper could be allowed to access the marine terminal files to determine if a container is in the inventory, its status, and its expected shipment date. Response to such an inquiry could be handled automatically, with no labor cost incurred.

5.1.3 Data Exchange with Other Port Agencies

Various agencies and departments in the port have need for information contained in the marine terminal files. Information on cargo tonnages, commodities, etc., is needed not only for billing for such services as wharfage and dockage but also for statistical reporting, marketing, and other functions essential to the port authority. Electronic access to this information, as well as the ability to receive routine information accurately and promptly, would benefit the port authority and could be provided without the marine terminal's incurring additional cost.

5.1.4 Nationwide Data Exchange for Container Tracking

The establishment of a system for tracking the location and status of containers, whether in a marine terminal or aboard a ship, truck, or rail car, is a formidable task. For the system to succeed, cooperation is required from all parties involved in the shipment and handling of containers. It is mentioned here because, as previously stated, the marine terminal is a key focal point for exchange of intermodal data. The implementation of computer-based systems at a number of terminals and the establishment of electronic data exchanges with carriers would be important stimuli in establishing a container tracking system.

5.2 SHARING OF COMPUTER RESOURCES

The requirements for a marine terminal management control system, described in Chapter Two of this report, address the flow of containers within the physical and operational boundaries of the terminal: gate to ship for export cargo, and ship to gate for import cargo. The same boundaries apply for the concepts presented in Chapter Three for automating the control process. Thus it is implied that the automated system described would be totally resident at a single terminal and dedicated to the terminal control function.

A question frequently raised when a port or marine terminal is considering acquisition of a computer system is whether the functions of that system could be combined with others under consideration by the port or terminal into a single, larger computer, thus effecting some economy in capital investment. Another question, particularly with regard to a system such as the one described in Chapter Three, is whether a number of marine terminals might pool their resources to share a single, larger control computer and thus reduce their individual capital investments and operating costs.

Consideration of these questions gives rise to a number of possibilities for sharing computer resources. Each should be examined by a port or terminal planning an automated system, and the alternatives should be analyzed and compared to arrive at an approach that is cost-effective for the particular application. Such an analysis must take into account the specific characteristics of the terminal in question and the options available to it.

Although quantitative treatment of the issue of shared resources is beyond the scope of this project, the prospects for sharing have been considered and the following concepts have been addressed:

- Shared central computer using commercial time-sharing services
- Central computer shared with other port functions
- Central computer shared by multiple marine terminals in the port
- Central computer shared by multiple marine terminals operated by the same company but geographically separated

These concepts are briefly addressed, in terms of advantages and disadvantages, in the following subsections.

5.2.1 Commercial Time-Sharing Services

In recent years the use of time-sharing services for certain computer applications has become extremely popular. Time sharing offers many advantages, including the following key ones:

- Capital investment is minimal. The user need only provide a data terminal device for input and output with the computer, and a communications link (usually a telephone line).
- The user pays only for the services he uses. Whether he needs a large computer or a small computer for a particular application, he pays only for the actual time he is connected and the actual processing time of the computer he selects, as well as a service charge for retention of any files.
- The user need not be concerned with obsolescence. As newer, more efficient and economical computers come on the market, the service company can upgrade its central computer as appropriate. The user is not faced with the problem or the cost of upgrading his own system and disposing of the system being replaced.

For an automated marine terminal management control system, however, it is unlikely that commercial time sharing would provide an attractive solution. Time sharing is most suitable for off-line, non-real-time applications. A terminal control system requires real-time access to the system data files and constant connection to the central computer service during operating hours. Therefore, the user would probably find himself paying for considerably more computer capacity than he needs for his

application. In addition, his response time from the computer would probably be unsatisfactorily slow because he would always be contending with other users for access to the computer and the data files.

5.2.2 Computer Shared with Other Port Functions

More and more types of port information are being computerized as information needs rise and computer costs fall. Payroll, bookkeeping, billing, planning, marketing, financial reporting, and many other functions are easily handled by a computer, and the use of computer systems to perform those functions is becoming widespread. Accordingly, the terminal operator wishing to automate his terminal control process must consider whether his needs can be integrated with those of other port departments to economize on computer investments.

Certainly, each case must be examined and analyzed for the particular port application at hand. In many cases, however, the terminal operator may find that a port-wide system has drawbacks similar to those of a commercial time-sharing service in that he is contending with other users and may get slow response as a result. Further, the systems that are optimal for other port functions are likely to be oriented toward management information systems, not requiring real-time, on-line data access as a terminal management control system does. Thus, by combining functions on a single computer system, the port may find it has purchased a system that is suboptimal for many applications while providing little or no overall savings.

An alternative that may be attractive in some port applications is to acquire a computer that is dedicated to the terminal control function during terminal operating hours and used for other functions during off-hours. With proper scheduling of use, the port authority may find that it can meet its needs with a much less costly system than one that would serve many users (including the marine terminal's real-time control) simultaneously during prime working shifts.

A number of the ports visited in the survey were strictly landlord ports, operating no marine terminals but providing some services to tenant terminal operators, ranging from gate control to crane operation. Some of these were considering investing in automated terminal management control systems and providing them as an additional service to the terminal operators. It had not been decided whether they would employ a single computer for multiple marine terminals or separate computers at each, how the terminals would be billed for use, or other issues that must eventually be resolved. The port's motivation for making such an investment is basically twofold: (1) to improve operations, reduce costs, and stimulate trade through the port; and (2) to have access to improved statistical information on cargo movements that can be used for port planning and marketing activities.

5.2.3 Multi-Terminal Computer Sharing at Same Port

One consideration greatly affecting the efficiency of a number of marine terminals in a port sharing a computer system is the degree of

commonality of information among them. If there is little or no commonality, each terminal will require completely separate data files and the situation will be similar to a commercial time-sharing arrangement, with the individual terminals contending for the computer on a time-shared basis. On the other hand, if there is a large amount of common information or much information is exchanged among the terminals, a shared computer might be more attractive.

Security of information must be a prime consideration in any system that is shared by multiple terminals. Certain data regarding shippers, cargo type, cargo tonnage, etc., may be considered proprietary by the booking steamship line. The more users there are for the computer system, the greater the possibility of inadvertent disclosure. This is not an insurmountable problem, because adequate security provisions can be built into the system, but it must be considered in the system design.

5.2.4 Multi-Terminal Computer Sharing by One Operating Company

The concept of a single terminal-operating company sharing a computer system among marine terminals in different ports is more applicable to steamship line-operated terminals than to public ones. A number of shiplines currently have some form of a shared system for tracking location and status of containers in their inventory. In these cases, there is considerable commonality of information and no security problem.

It is less likely, however, that a group of geographically separated public marine terminals would have a need for much exchange of information on containers, even if they were operated by the same operating company. The terminal operator is concerned principally with his responsibility to safeguard and move a container through his terminal; he would not have enough information on all moves of that container outside his terminal to provide an effective tracking function.

Even those shared systems operated by shiplines are not truly real-time control systems of the type described in Chapter Three. If those lines implemented automated control, they would probably consider employing some form of a distributed network configuration, with small computers at each terminal performing the real-time control function and providing inventory and status data to the central computer system.

5.3 SUMMARY

The concept of an automated marine terminal management control system can be extended beyond the boundaries of the terminal itself in two areas: extending the use of information associated with the automated system and sharing computer resources among multiple users.

The exchange of information associated with marine terminal control can benefit the terminal itself as well as the parties in the exchange. An automated system can provide an important stimulus to establishing the

electronic exchange of container-related data with sea and land carriers, shippers, and various agencies within the port, and can be an important element in a nationwide container-tracking system.

The sharing of computer resources for real-time marine terminal control must be evaluated for each situation. While economies in capital investment may be possible, the resulting system may be sub-optimal for each of the sharing users and may provide response times that are not tolerable for real-time applications.

CHAPTER SIX

PROGRAM PLAN FOR PHASE II

This chapter sets forth a preliminary plan for Phase II of the Automated Management Control System Program. The objective of the Phase II effort is to complete the design of an experimental automated terminal management control system, install and demonstrate operation of the experimental system in a public marine terminal, and evaluate the system operation to form the basis for developing system specifications and a cost-benefit analysis package during Phase III of the program.

Successful completion of Phase II will require the participation of three separate agencies or organizations:

- The Maritime Administration (MarAd)
- The system contractor
- The demonstration terminal

The nature and extent of participation by each of these organizations is described later in Section 6.3.

6.1 DESCRIPTION OF TASKS

The tasks to be completed during Phase II are described in the following subsections. The schedule for their completion is presented in Section 6.2.

6.1.1 Task 1: Project Planning

The purpose of Task 1 is to complete the planning necessary to assure the efficient and timely completion of subsequent tasks. The first activity of this task will be to make the final selection of the demonstration terminal so that the necessary planning can take place. Representatives of MarAd, the system contractor, and the demonstration terminal will then work jointly to prepare a plan defining the following:

- Specific activities to be performed
- Schedule of activities

- Responsibilities of participants (MarAd, system contractor, and demonstration terminal)
- Methods to be used in assessing performance
- Data to be collected during demonstration

The detailed project plan will be prepared in final form by the system contractor and submitted for review and approval by MarAd and the demonstration terminal.

6.1.2 Task 2: Final System Design

The design concepts defined during Phase I and documented in this final report will be the basis for a detailed design of the experimental system to be used for the operational demonstration. This design will address the specific system configuration for the demonstration terminal, including:

- Computer system requirements (central processor and communications interface)
- Number and location of peripheral devices (input/output terminals, printers, digital displays, etc.)
- System software requirements (logic diagrams, flow charts, file structures, data specifications, etc.)

The product of the system design task will be a system description or specification suitable for procurement, installation, and checkout/acceptance of necessary system hardware and software during Tasks 3, 4, and 5.

6.1.3 Task 3: System Hardware Procurement

The specific system components of the experimental system will be identified from the system description and/or specification developed during Task 2. For reasons of economy, first consideration will be given to equipment already owned by the demonstration terminal and available and suitable for use. This equipment will be incorporated directly into the experimental system, or modified and incorporated, whenever such action is technically feasible and represents a cost saving in comparison with the purchase of new equipment.

For new components, the source of supply will be selected and the components will be procured on a favorable cost and schedule basis. Any necessary pre-delivery testing or demonstration performed by the supplier will be witnessed and monitored by the system contractor. Certain of the system components will be delivered directly to the demonstration terminal, while others will be first delivered to the contractor's facility for pre-installation testing; as determined on the basis of both technical and economic considerations.

It is expected that most system maintenance, particularly for major components, will be performed by the component supplier under a standard warranty or maintenance contract. For maintenance actions that can be performed by terminal personnel, appropriate maintenance instructions will be procured, together with the hardware components, and arrangements will be made for necessary training.

6.1.4 Task 4: System Software Development

The software packages or modules necessary for the experimental system will be identified on the basis of the system description or specification developed during Task 2 and the specific hardware components identified during Task 3. As with the hardware, first consideration will be given to software that is already owned by the demonstration terminal and is available and suitable for use.

For new software, a determination will be made as to the extent to which commercially available software packages, such as file management modules, can economically satisfy system requirements. Where new software is necessary, a decision whether to develop or purchase it will be made on the basis of the most favorable approach from the standpoint of time and cost.

6.1.5 Task 5: System Installation and Checkout

During the installation and integration of system components at the demonstration terminal, terminal personnel who will operate and maintain the system will be kept closely involved in the system familiarization and training process.

After the system is installed and integrated, sufficient system tests and sample operations will be performed to assure that the system is ready for cutover to full-time operation. This checkout period will be used to provide additional training to the terminal personnel who will operate and maintain the system. Operator's instructions will be prepared for use as training and reference materials.

6.1.6 Task 6: System Operation and Data Collection

When system checkout and operator training have been completed, the experimental system will be cut over to full-time operation. To the extent possible, the cutover will be scheduled during an off-peak period to minimize the impact on terminal operations.

The system demonstration period will extend for six months following cutover. The system contractor will provide on-site representation at the demonstration terminal during the first month of this period to monitor initial operations, coordinate the resolution of problems, and supervise initial data collection. After the first month, the system contractor will visit the demonstration terminal at least every two weeks to witness system operation, discuss problems and coordinate their resolution, and collect data accumulated by terminal personnel.

6.1.7 Task 7: System Evaluation

After the Project Plan (Task 1) is approved by MarAd, collection of data representing pre-automation terminal performance will commence. Beginning at cutover, data dollected during automated system operation will be used to perform a continuous evaluation of performance in accordance with the methodology defined in the Project Plan.

Throughout the demonstration period, in addition to the collection and recording of data for the quantitative evaluation, a log will be maintained to note all system deficiencies identified, problems encountered, and solutions implemented. This information will be the basis for developing recommendations for modifications or improvements to the system design to be considered during Phase III of the program.

6.1.8 Task 8: Project Documentation

The results of the activities of the preceding seven tasks will be documented by the system contractor in a final report to MarAd. The report will include a discussion of the activities conducted, an assessment of system performance during the demonstration, conclusions and recommendations derived from the task results, and a recommended plan for Phase III of the program.

6.2 SCHEDULE

The anticipated schedule for the tasks described in Section 6.1 is shown in Figure 6-1. It must be recognized that certain of the tasks are dependent on timely performance by suppliers (e.g., Tasks 3, 4, and 5); however, discussions with potential suppliers of the type of hardware and software expected to be used have indicated that the schedule shown is realistic. It is expected that the necessary planning, design, procurement, installation, and checkout activities can be completed in the first seven months, with system operation to begin in the eighth month. It is estimated that the overall Phase II program can be completed in sixteen months.

6.3 RESPONSIBILITIES OF PARTICIPANTS

The Phase II program will be jointly funded by the Federal Government (MarAd) and the maritime industry (the demonstration terminal). The exact amount of funding to be supplied by each party will be determined through discussions and negotiations between MarAd and the selected terminal.

The detailed responsibilities of the participants will be fully defined in the Project Plan to be jointly prepared by MarAd, the system

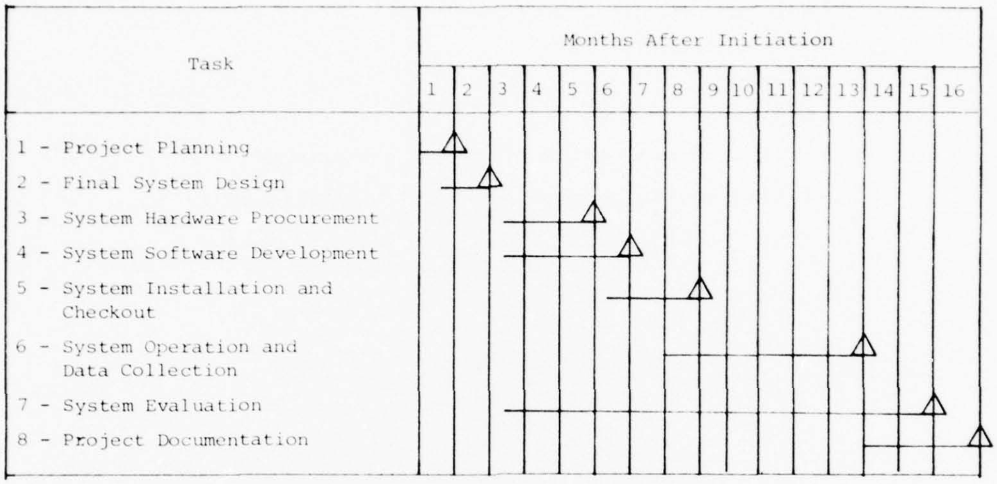

Figure 6-1. PHASE II SCHEDULE: AUTOMATED MANAGEMENT CONTROL SYSTEM FOR PUBLIC MARINE TERMINALS

contractor, and the demonstration terminal during Task 1. The broad responsibilities are expected to be as follows:

- Marad
  - •• Provide overall project management and direction
  - •• Exercise approval authority on plans and reports
  - •• Execute and fund contractual relationship with system contractor
- System Contractor
  - •• Coordinate and prepare project plan
  - •• Prepare final system design for demonstration terminal
  - •• Assist demonstration terminal in selection and procurement of hardware and packaged software
  - •• Perform system integration and checkout
  - •• Supervise system installation and initial operation
  - •• Evaluate system performance
  - •• Prepare report documenting results
- Demonstration Terminal
  - •• Participate in project planning
  - •• Provide consultation and advice during final system design
  - •• Procure system hardware and packaged software

- Provide necessary facilities for system installation (space, power, cabling, etc.)
- Provide necessary personnel for system installation, operation, and maintenance
- Assist in evaluation of system performance
- Retain system at conclusion of demonstration

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The following conclusions have been reached on the basis of the project results:

- Our analysis of the requirements for controlling the flow of containerized cargo through a marine terminal has indicated that it is feasible to configure an automated (computerized) control system to satisfy these requirements.
- An automated control system must have the following general characteristics:
  - Central control of the flow of information regarding the status of containers, yard equipment, storage locations, or any other terminal facilities associated with the processing and movement of containers within the terminal
  - Timely acquisition of accurate data from operational nodes in the terminal, and transmission of appropriate data to enhance performance of operations at the nodes
  - Storage of current status information on containers, yard equipment, storage, locations, and other terminal facilities
  - Access to stored information to serve a variety of real-time inquiries and routine reporting requirements
- The costs and benefits associated with acquiring and operating an automated terminal control system can be analyzed by using the methodology developed during the project. Application of the analysis methodology must take into account the parametric values of the characteristics associated with the terminal under consideration. Preliminary exercises, using values for the parameters that are considered to be representative, have shown an extremely favorable relationship between benefits and costs and an attractive rate of return on investment.
- Implementation of an automated control system can provide a beneficial means for establishing electronic data exchange between the marine terminal and carriers (water and land), shippers, and other

agencies in the port; it can also be an important element in a nationwide exchange of container location and status data.

- Shared computer resources for automating control of multiple marine terminals, or sharing a computer between a terminal control system and other, non-real-time users must be evaluated on a case-by-case basis; such sharing could result in a sub-optimal system for each user and intolerable response time for the terminal control system.
- The requirements and concepts defined for an automated terminal management control system and the favorable cost-benefit relationships indicated from preliminary analyses justify a MarAd decision to proceed with a Phase II system demonstration.

7.2 RECOMMENDATIONS

The following actions are recommended:

- MarAd should proceed with Phase II of the program, the design and demonstration of a prototype system.
- The Phase II demonstration should take place at a public, multiple-user container terminal. The prototype system should employ a medium level of automation and should represent a low technical risk to maximize the potential for demonstrating the basic concept of automated management control.
- If the results of Phase II are favorable, Phase III should be undertaken to finalize system descriptions and analysis methods for use by public marine terminals.
- Efforts should be initiated to foster the development of means for electronically exchanging data between the marine terminal and the carriers (water and land), shippers, and other agencies in the port.
- The concept of a nationwide exchange of container location and status data should be investigated to determine its feasibility and the steps necessary to carry it forward.

APPENDIX A

CHARTER OF ATC INDUSTRY LIAISON COMMITTEE

INTRODUCTION

The Maritime Administration (MARAD) acting under its charter to promote the efficient and profitable operation of the U.S. merchant marine, is contemplating contracting with ARINC Research Corporation, to determine the need for, the cost benefits potential of and a practical design concept for an Automated Terminal Control System (ATCS), for use in the U.S. marine terminal industry.

NEED FOR AN ATCS INDUSTRY COMMITTEE

An industry liaison committee, consisting of knowledgeable and experienced marine terminal industry members is desired in order to ensure that the work to be undertaken in the ATCS project is both consistent with the actual needs of the industry, and that the ATCS concept ultimately recommended is within the resources of the industry to implement.

RESPONSIBILITIES OF THE ATCS INDUSTRY LIAISON COMMITTEE

The ATCS Industry Liaison Committee will:

- Review the reports (e.g., monthly letter progress reports) published by the contractor throughout the project and advise MARAD and the contractor as to the validity of the reports and the approach being followed.
- Consult with MARAD and the contractor as to the direction of the development effort to ensure that the results of the work undertaken are of significant value to the industry.
- During the initial stage of the program, provide assistance to the contractor through demonstration of the information flow and procedures followed at their respective terminals.

THE MEMBERSHIP OF THE INDUSTRY LIAISON COMMITTEE

The Industry Committee will consist of at least one member each from the Maritime Terminals Inc. (MTI) at the Norfolk International Terminal and the Maryland Port Administration (MPA) of the Port of Baltimore. A distribution of experience in the areas of marine terminal operations, data processing, and finance is sought in the makeup of the committee.

LEVEL OF SUPPORT REQUIRED

Each element (i.e., MTI and MPA) of the Industry Committee is requested to devote 2 days per month to the project for the first 5 months, one manday per month for the next 6 months and 2 mandays during the twelfth month. The total manday commitment of each element of the Industry Committee during the 12 month contract is therefore 18 mandays. It is fully recognized that the workloads and schedules of individual committee members may serve to both reduce or increase the actual level of support provided.

LEVEL OF TRAVEL REQUIRED

Four (one-day duration) meetings of the Advisory Committee will be scheduled during the 12 month contract period (1 per quarter). The meetings will be rotated in their location in order to minimize the travel burden on any single element of the work team. Consequently they will be held at Washington, D.C., Norfolk, Baltimore, and Annapolis. The Committee members will be notified well in advance of the date, time, location and agenda for the meetings.

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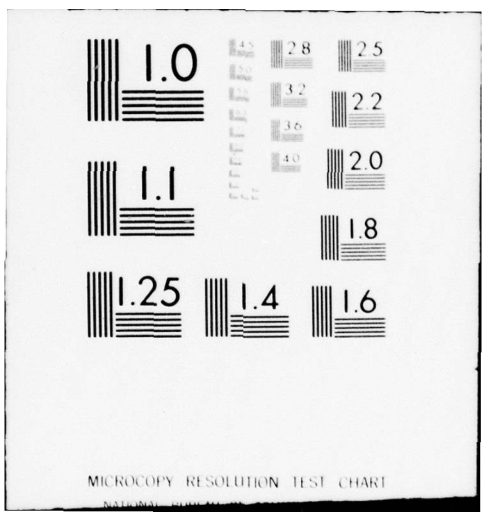
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MICROCOPY RESOLUTION TEST CHART

APPENDIX B

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APPENDIX C

SAMPLE OF TERMINAL SURVEY INTERVIEW PACKET

AUTOMATED TERMINAL
MANAGEMENT CONTROL
PROJECT

MARAD/ARINC RESEARCH CORPORATION

TERMINAL SURVEY RECORD

TERMINAL ______________________

LOCATION ______________________

SHIP LINE(S) ______________________

DATE ______________________

ACTC PROJECT

TERMINAL SURVEY VISIT
TENTATIVE AGENDA

- Briefing to interested officials
- Discussion of terminal operations and statistics
- Tour of Terminal
- Observation of operations
  - Office/Clerical
  - Gate
  - Apron
  - Storage area
  - Stuffing/Stripping
  - Customs and other government facilities
  - Brokers/forwarders
- Exit briefing

TERMINAL ____________________ LOCATION ____________________________

TERMINAL ADDRESS ________________________

TERMINAL/PERSONNEL

Title	Name	Address If different from Terminal	Telephone No.

TERMINAL ______________________ LOCATION ________________________

Physical Data

	No.	Kind/Capacity
Berths:		
. Container		
. Break Bulk		
Warehouses		
Container Storage Areas		
. Chassis		
. Ground		
Cranes		
Transtainers		
Straddle Carriers		
Hustlers		
Gates		
Scales		
Railtracks		
Proximate rail terminals		
Parking (Chassis)		
Tonnage, per year		
Containers, per year (TEU)		
Value of Cargo, $ per year		

TERMINAL ______________________________ LOCATION__________________________________

Tenancy/Support Relationships

Port Authority ____

Terminal Owner ____

Terminal Operator(s) ____

____

____

____

____

____

Terms of tenancy (including responsibility of Port Authority)

Tenancy/Support Relationships (cont'd)

Using Shiplines

Supporting T/Ls

Supporting RRs

Drayage Companies

Tenancy/Support Relationships (cont'd)

Stevedores

TERMINAL ______________________________ LOCATION ______________________________

Management Information System

Computer

Core Memory

Mass Memory

Architecture

Computer Functions

Input Devices (Type, location, by whom operated, etc)

Output Devices (Type, location, by whom operated, etc)

Data link description

Reports

Work Orders

Billing documents

Miscellaneous data, e.g. government requirements

New Technology

TERMINAL ______________________ LOCATION ______________________

Export/Import Flow Diagram, Containers. By Road

TERMINAL ______________________________ LOCATION ______________________________

Export/Import Flow Diagram, Containers, By Rail

TERMINAL ______________________________ LOCATION ________________________________

Export/Import Flow Diagram, Information, By Road

TERMINAL ______________________ LOCATION ________________________

Export/Import Flow Diagram, Information, By Rail

TERMINAL ______________________ LOCATION ______________________

SHIPLINE ______________________

List forms and documents - by title

APPENDIX D

DETAILED TERMINAL OPERATIONS

Tables D-1 through D-23 present the detailed action steps for each basic operation, the type of message (or information transfer) associated with each step, the nodes (operational stations in the terminal) involved in originating and receiving the message, and the data elements contained in the message.

Table D-1

Operation: 1 - Weigh-In

Movement: Export

Nodes Involved: 1 - Control Center
4 - Scale

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Weigh	Send weight data	4	1	Scale ID format	EIR sequence number, shipline, scale weight, carrier, tractor license number, tractor tare, chassis number, chassis tare, container number, container tare, container type(s), scale operator I.D., DTG

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Table D-2

Operation: 2 - Bobtail in for Empty Container and Chassis

Movement: Export

Nodes Involved: 1 - Control Center; 2 - Gate;
3 - Parking Area; 7 - Empty Chassis Storage
8 - Empty Container Storage
11- Hustlers/Straddle Carriers

Action	Message	Calling Node	Receiving Node				Data Elements	
							Message Control	Action
Gate ask for booking number	Request for booking confirmation	2	1				Booking request format	Carrier, booking number
Program sets up TLF, including container number	Booking confirmation	1	2				Booking confirmation format	Yes-No, if yes, container number
Obtain tractor license number, driver's ID, carrier ID	Record tractor terminal entry	2	1				Tractor location format	Tractor license number, tractor driver's ID, carrier, Terminal Area (gate)
Gate pass printed given to driver	Gate pass message	1	2				Gate pass format	Tractor license number, tractor driver's ID, carrier, terminal area (destination), container number, DTG
Send yard hustler for empty chassis	Dispatch hustler, info to empty chassis storage area	1	11	7			Hustler dispatch format	Several Options: 1. Empty chassis storage location 2. Empty chassis storage area
Hustler picks up chassis	Status change message	11	1	7			Hustler status format	Chassis number, empty chassis storage location, DTG
Send hustler to empty container storage area	Dispatch hustler to empty container storage area, info to transtainer and storage area	1	11	8			Hustler dispatch format	1. Empty container number, empty container storage location
Hustler picks up container	Status change message	11	1	8			Hustler status format	
Send hustler and container to transfer point	Dispatch hustler, info to transfer point (parking area)	1	11	3			Hustler dispatch format	Terminal Area (Transfer Point)
Tractor arrives at transfer point	Record tractor position	3	1				Tractor location format	DTG
Tractor and hustler exchange container	Status change message	11	1	3			Hustler status	DTG
Truck proceeds to interchange								

Table D-3

Operation: 3 - Rail Car Unloading

Movement: Export

Nodes Involved: 1 - Control Center; 5 - TOFC/COFC Ramp;
7 - Empty Chassis Storage;
10 - Transtainers
11 - Hustlers/Straddle Carriers

Action	Message	Calling Node	Receiving Node		Data Elements: Message Control	Data Elements: Action
Send yard hustler for empty chassis	Dispatch hustler, info to empty chassis storage area	1	11	7	Hustler dispatch format	Several Options: 1. Empty chassis storage location 2. Empty chassis storage area
Hustler picks up chassis	Status change message	11	1	7	Hustler status format	Chassis number, empty chassis storage location, DTG
Hustler and chassis to TOFC/COFC	Dispatch hustler to TOFC/COFC, info to TOFC/COFC	1	11	5	Hustler dispatch format	Terminal area (TOFC/COFC)
Send transtainer to TOFC/COFC	Dispatch hustler to TOFC/COFC, info to TOFC/COFC	1	10	5	Transtainer dispatch format	Terminal area (TOFC/COFC)
Container transferred to hustler and chassis	Status change	11	1		Hustler status format	Container number, DTG
	Status change	5	1		Container status	Container number, yard equipment (hustler) serial number, DTG
Hustler to scale for weigh in						

Table D-4

Operation: 4 - Full Container from Parking Area to Storage

Movement: Export

Nodes Involved: 1 - Control Center; 3 - Parking Area;
9 - Full Container Storage;
11 - Hustlers/Straddle Carriers

Action	Message	Calling Node	Receiving Node			Data Elements	
						Message Control	Action
Send yard hustler to parking area	Dispatch hustler, info to parking area and container on chassis storage	1	11	3	9	Hustler dispatch format	Terminal location (Parking area)
Hustler pick up container on chassis	Status change message	11	1			Hustler status format	Container number, chassis number, DTG
	Status change message	3	1			Chassis/Container status change format	Chassis number, container number, DTG
Hustler parks container and chassis	Status change message	11	1			Hustler status format	DTG
Report chassis and container location	Chassis/container status change message	9	1			Chassis/container status change message	Chassis number, container number, container storage location, chassis storage location

Table D-5

Operation: 5 - Gate Admittance

Nodes Involved: 1 - Control Center
2 - Gate

Movement: Export

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Trucker presents weight ticket	Create gate permit	2	1	Gate permit creation format	DTG (in), tractor license number, carrier, tractor driver ID, shipline, chassis number, container number, terminal employee ID
Print gate pass and give driver copy. Direct driver to interchange area					

Table D-6

Operation: 6 - Interchange

Movement: Export

Nodes Involved: 1 - Control Center
6 - Interchange Station

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Trucker presents gate permit	Create interchange agreement	6	1	Request interchange creation format	Shipline
Inspect container and chassis	If fault found, notify maintenance	6	15	Maintenance required format	Container/chassis numbers, container/chassis condition
Fill out interchange agreement	Interchange agreement data	6	1	Interchange agreement format	Container number, EIR sequence number, shipline, chassis number, chassis license number, seal number, tractor license number, tractor driver ID, carrier, container tare, container type, container length, container gross weight, container owner/lessee, container height, container condition, chassis tare, chassis type, chassis length, chassis owner/lessee, chassis condition, terminal employee ID, DTG
Give driver a copy					

Table D-7

Operation: 7 - Dock Receipt Execution

Movement: Export

Nodes Involved: 1 - Control Center
3 - Parking Area

Action	Message	Calling Node	Receiving Node	Data Elements	
				Message Control	Action
Truck driver directed to parking slot	Location of truck, chassis, and container	3	1	Container/chassis/ tractor location format	Tractor license number, container number, chassis number, terminal area, DTG
Truck driver produces dock receipt	Dock receipt information	3	1	Dock receipt format	Exporter, consignee, document number, forwarder/ agent, origin, shipline, booking number, voyage number, latest pier delivery date, terminal, vessel, port of loading, port of discharge, transshipment port, marks and numbers, number of packages, container number, seal number, container type, terminal employee ID
Driver receives signed copy of dock receipt					Truck driver ID

Table D-8

Operation: 8 - Full Container from Storage to Apron

Movement: Export

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers

Action	Message	Calling Node	Receiving Node				Data Elements	
							Message Control	Action
Send yard hustler to container on chassis storage area	Dispatch hustler, info to container on chassis storage	1	11	9			Hustler dispatch format	Terminal area
Hustler picks up container on chassis	Status change message	11	1				Hustler status format	Container number, chassis number, DTG
	Container/Chassis status change message	9	1				Container/chassis status format	Container number, chassis number, DTG
Container is lifted from chassis by gantry crane	Status change message	11	1				Hustler status format	Container number, DTG

Table D-9

Operation: 9 - Empty Container to CFS to Full Container Storage

Movement: Export

Nodes Involved: 1 - Control Center; 7 - Empty Chassis Storage
9 - Full Container Storage;
11 - Hustlers/Straddle Carriers
12 - Container Freight Station (CFS)

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Send yard hustler for empty chassis	Dispatch hustler info to empty chassis storage area	1	11, 7	Hustler dispatch format	Several Options: 1. Empty chassis storage location 2. Empty chassis storage area
Hustler picks up chassis	Status change message	11	1	Hustler status format	Chassis number, DTG
	Status change message	7	1	Chassis status format	Chassis number, empty chassis storage location, DTG
Send hustler to pick up empty container	Dispatch hustler to empty info to DFS container storage	1	11, 12	Hustler dispatch format	Empty container number, terminal area
Hustler picks up container	Status change message	11	1	Hustler status format	Container number, DTG
	Status change message	12	1	Container status format	Container number, terminal area, DTG
Hustler drops container at CFS	Status change message	11	1	Container status format	Container number, terminal area, DTG
Hustler picks up full container at CFS	Status change message	11	1	Container status format	Container number, terminal area, DTG
Send hustler and container to container on chassis storage	Dispatch hustler, info container on chassis storage	1	11, 9	Hustler dispatch format	Container number
Drop container and chassis at storage area	Status change message	11	1	Hustler status	Terminal area, DTG
	Status change message	9	1	Container status and chassis status format	Container number, chassis number, container storage location, DTG

Table D-10

Operation: 10 - Ship Loading

Nodes Involved: 1 - Control Center
17 - Crane

Movement: Export

Action	Message	Calling Node	Receiving Node	Data Elements	
				Message Control	Action
Load the ship	Identify container loaded, hatch number, shipline, etc.	16 or 17	1	Load format	Container number, shipline, vessel hatch number, shipline employee ID (accepting cargo), DTG

Table D-11

Operation: 11 - Rail Car Loading

Movement: Import

Nodes Involved: 1 - Control Center
5 - TOPC/COFC Ramp
9 - Full Container Storage

Action	Message	Calling Node	Receiving Node		Data Elements: Message Control	Data Elements: Action
Send yard hustler for container at container on chassis storage	Dispatch hustler, info to container on chassis storage	1	11	9	Hustler dispatch format	Terminal area
Hustler picks up chassis and container	Status change message	11	1	7	Hustler status format	Chassis number, empty chassis storage location, DTG
	Status change message	11	1		Chassis/container status/format	Container number, chassis number, storage location, DTG
Hustler container and chassis to TOPC/COFC	Dispatch hustler to TOPC/COFC, info to TOPC/COFC	1	11	5	Hustler dispatch format	Terminal area (TOPC/COFC)
Send transtainer to TOPC/COFC	Dispatch hustler to TOPC/COFC, info to TOPC/COFC	1	10	5	Transtainer dispatch format	Terminal area (TOPC/COFC)
Container transferred to rail car	Status change	11	1		Hustler status format	Container number, DTG
	Status change	5	1		Container status	Container number, hustler number, DTG

Table D-12

Operation: 12 - Full Container from Fumigation to Storage

Movement: Import

Nodes Involved: 1 - Control Center; 7 - Empty Chassis Storage
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
14 - Fumigation Shed

Action	Message	Calling Node	Receiving Node		Data Elements	
					Message Control	Action
Send yard hustler for empty chassis	Dispatch hustler, info to empty chassis storage area	1	11	7	Hustler dispatch format	Several Options: 1. Empty chassis storage location 2. Empty chassis storage area
Hustler picks up chassis	Status change message	11	1		Hustler status format	Chassis number, DTG
	Status change message	7	1		Chassis status format	Chassis number, empty chassis storage location, DTG
Send hustler to fumigation	Dispatch hustler to fumigation, info to fumigation	1	11	14	Hustler dispatch format	Terminal area
Hustler picks up container	Status change message	11	1		Hustler status format	Container number, DTG
	Status change message	14	1		Container status format	Container number, terminal area DTG
Send hustler and container to container on chassis storage	Dispatch hustler, info to container on chassis storage	1	11	9	Hustler dispatch format	Container number
Drop container and chassis at storage area	Status change message	11	1		Hustler status format	Terminal area, DTG
	Status change message	9	1		Container status and chassis status format	Container number, chassis number, container storage location, DTG

Table D-13

Operation: 13 - Full Container from Storage to Fumigation

Movement: Import

Nodes Involved: 9 - Full Container Storage
11 - Hustlers/Straddle Carriers
14 - Fumigation Shed

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Send hustler to container on chassis storage	Hustler dispatch	1	11, 9	Hustler dispatch format	Container number, container storage location
Hustler picks up chassis and container	Status change message	11	1	Hustler status format	Container number, chassis number
	Status change message	9	1	Container/chassis status format	Container number, chassis number, DTG
Send hustler to fumigation	Dispatch hustler, info to fumigation	1	11, 14	Hustler dispatch format	Terminal area
Leave container/ chassis at fumigation	Status change message	11	1	Hustler status format	Container number, DTG
	Status change message	14	1	Container status format	Terminal area, DTG

Table D-14

Operation: 14 - Full Container from Storage to Customs

Movement: Import

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
13 - Customs/USDA

Action	Message	Calling Node	Receiving Node		Data Elements: Message Control	Data Elements: Action
Send hustler to container on chassis storage	Hustler dispatch	1	11	9	Hustler dispatch format	Container number, container storage location
Hustler picks up chassis and container	Status change message	11	1		Hustler status format	Container number, chassis number
	Status change message	9	1		Container/chassis status format	Container number, chassis number, container storage location, DTG
Send hustler to Customs	Dispatch hustler, info to CFS	1	11	13	Hustler dispatch format	Terminal area
Leave container/chassis at customs	Status change message	11	1		Hustler status format	Container number, DTG
	Status change message	13	1		Container status format	Terminal area, DTG

Table D-15

Operation: 15 - Full Container from Customs to Storage

Movement: Import

Nodes Involved: 1 - Control Center
7 - Empty Chassis Storage
9 - Full Container Storage

Action	Message	Calling Node	Receiving Node				Data Elements	
							Message Control	Action
Send yard hustler for empty chassis	Dispatch hustler, info to empty chassis storage area	1	11	7			Hustler dispatch format	Several Options: 1. Empty chassis storage location 2. Empty chassis storage area
Hustler picks up chassis	Status change message	11	1				Hustler status format	Chassis number, DTG
	Status change message	7	1				Chassis status format	Chassis number, DTG
Send hustler to customs	Dispatch hustler to customs, info to customs	1	11	13			Hustler dispatch format	Empty container number, terminal area
Hustler picks up container	Status change message	11	1				Hustler status format	Container number, DTG
	Status change message	13	1				Container status format	Container number, terminal area, DTG, seal number
Send hustler and container to container on chassis storage	Dispatch hustler, info to container on chassis storage	1	11	9			Hustler dispatch format	Container number
Drop container and chassis at storage area	Status change message	11	1				Hustler status format	Terminal area, DTG
	Status change message	9	1				Container status and chassis status format	Container number, chassis number, storage location, DTG

Table D-16

Operation: 16 - Full Container from Storage to CFS for Stripping

Movement: Import

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
12 - Container Freight Station (CFS)

Action	Message	Calling Node	Receiving Node				Data Elements: Message Control	Data Elements: Action
Send hustler to container on chassis storage	Hustler dispatch	1	11	9			Hustler dispatch format	Container number, container storage location
Hustler picks up chassis and container	Status change message	11	1	12			Hustler status format	Container number, chassis number, DTG
	Status change message	9	1				Container/chassis status format	Container number, chassis number, container storage location, DTG
Send hustler to CFS	Dispatch hustler, info to CFS	1	11	12			Hustler dispatch format	Terminal area
Leave container/chassis at CFS	Status change message	11	1				Hustler status format	DTG
	Status change message	12	1				Container on status format	Terminal area, DTG

Table D-17

Operation: 17 - Empty Container from CFS to Empty Container Storage

Movement: Import

Nodes Involved:
1 - Control Center
8 - Empty Container Storage
11 - Hustlers/Straddle Carriers
12 - Container Freight Station (CFS)

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Notify control center that container is available for pickup at CFS	Status change message	12	1	Container status format	Terminal area, container number, DTG
Send hustler to CFS	Dispatch hustler, info to CFS	1	11, 12	Hustler dispatch format	Terminal area (CFS)
Hustler picks up empty container/chassis	Status change message	11	1	Hustler status format	Container number, chassis number, DTG
	Status change message	12	1	Chassis/container status format	Container number, chassis number, terminal area, DTG
Send hustler to empty container storage	Dispatch hustler, info to empty container storage area	1	11, 8	Hustler dispatch format	Terminal area
Hustler container placed in storage	Status change message	11	1	Hustler status format	DTG
	Status change message	8	1	Container status format	Container number, container storage location, DTG

Table D-18

Operation: 18 - Ship Discharge

Movement: Import

Nodes Involved: 1 - Control Center
16 - Apron

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Discharge	Container sequence list	16	1	Sequence list format	Vessel, shipline, seal number, container number, container length, container type, container height, chassis number, terminal employee ID, DTG

Table D-19

Operation: 19 - Container from Apron to Storage

Movement: Import

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
16 - Apron

Action	Message	Calling Node	Receiving Node				Data Elements	
							Message Control	Action
Direction to place container in storage	Hustler dispatch	1	11	9			Hustler dispatch format	Container number, container storage location
Container loaded on hustler/chassis	Status change message	11	1				Hustler status format	Container number, DTG
Hustler parks chassis and container	Status change message	11	1				Hustler status change format	Container number, chassis number, DTG
Report chassis and container location	Container/chassis status change message	9	1				Chassis/container status change format	Container number, chassis number, container storage location, DTG

Table D-20

Operation: 20 - Bobtail in for Full Container and Chassis

Movement: Import

Nodes Involved: 1 - Control Center; 2 - Gate;
3 - Parking Area; 9 - Full Container Storage
11 - Hustlers/Straddle Carriers

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Gate asks truck driver for delivery order, driver retains delivery order	Tractor has valid delivery order	2	1	Delivery order format	Carrier, delivery order number, container number, shipline, consignee (sufficient information to locate file absolutely), DTG
Obtain tractor license number, driver ID, carrier ID	Record tractor terminal entry	2	1	Tractor location format	Tractor license number, tractor driver ID, terminal area, DTG
Gate pass printed, given to driver	Gate pass message	1	2	Gate pass format	Tractor license number, tractor driver ID, carrier, terminal area, container number, DTG
Container pass printed, given to driver	Container pass message	1	2	Container pass format	Container number, storage location, seal number, chassis number, arrival (container), DTG, broker, delivery order DTG, carrier, booking number, shipline, container type, container number, container height, container length, container moves, customs status, cargo weight, cargo cube, fumigation DTG, cargo description, vessel, voyage, broker reference number, freight payer, freight charge status, shipper, shipper's address, consignee, consignee's address, delivery order number, container tare, move DTG, pass DTG, hazard code, direction (import/export), type shipment (H,H), (P,P), etc.
Send hustler to container on chassis storage	Dispatch hustler, info to container on chassis storage	1	11 9	Hustler dispatch format	Storage location, container/chassis number
Hustler picks up container and chassis	Status change message	11	1	Hustler status format	Chassis number, container number, DTG, terminal area
	Status change message	9	1	Chassis/container status format	Chassis number, storage location area, DTG
Tractor picks up chassis and container, driver signs container pass terminal employee signs delivery order	Status change message	3	1	Tractor location format	Tractor license number, container number, chassis number, tractor driver ID, terminal employee ID, DTG, terminal area
	Status change message	3	1	Chassis/container status format	Container number, chassis number, storage location, DTG

Table D-20 Continued

Operation:

Movement:

Nodes Involved:

Action	Message	Calling Node	Receiving Node	Data Elements	
				Message Control	Action
Truck proceeds to interchange					

Table D-21

Operation: 21 - Interchange of Import Container and Chassis

Nodes Involved: 1 - Control Center
6 - Interchange Station

Movement: Import

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Trucker arrives at interchange	Create interchange agreement	6	1	Request interchange creation format	Shipline, DTG
Fill out interchange agreement		6	1	Interchange format	DTG, shipline, EIR sequence number, carrier, origin, terminal, seal number, container number, chassis number, container owner, chassis license number, tractor license number, container length, container type, container condition, chassis condition, remarks, truck driver ID, terminal employee ID
Give driver a copy					

Table D-22

Operation: 22 - Container Tagged for Customs Inspection

Nodes Involved: 1 - Control Center
13 - Customs/USDA

Movement: Import

Action	Message	Calling Node	Receiving Node	Data Elements	
				Message Control	Action
Customs selects container for inspection from ship's manifest	Customs tag message	13	1	Customs status format	Container number, customs status, DTG

Table D-23

Operation: 23 - Release of Container by Customs

Movement: Import

Nodes Involved: 1 - Control Center
13 - Customs/USDA

Action	Message	Calling Node	Receiving Node	Data Elements: Message Control	Data Elements: Action
Release cleared containers	Customs release message	13	1	Customs release format	Container number, customs status, seal number, customs employee ID

APPENDIX E

OPERATIONAL DATA ELEMENTS

Tables E-1 through E-23 present the variable characteristics of each data element involved in the operations defined in Chapter Two (the numbers of the tables correspond to the operation numbers). For each operation, all of the data elements involved are shown in the first column. The second column shows the length (in bytes) of each data element. All of the messages containing that data element are shown in the third column. The next two columns show the nodes sending and receiving that message, while the final two columns show the priority (or relative importance) and accuracy required of the particular data element in that message.

Table E-1

Operation: 1 - Weigh-In

Movement: Export

Nodes Involved: 1 - Control Center
4 - Scale

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
EIR Sequence Number	10	Weigh Data	4	1	High	Medium
Shipline	25	Weigh Data	4	1	High	Medium
Scale Weight	6	Weigh Data	4	1	High	Medium
Carrier	25	Weigh Data	4	1	High	Medium
Tractor License Number	8	Weigh Data	4	1	High	Medium
Tractor Tare	6	Weigh Data	4	1	High	Medium
Chassis Number	10	Weigh Data	4	1	High	Medium
Chassis Tare	6	Weigh Data	4	1	High	Medium
Container Number	10	Weigh Data	4	1	High	Medium
Container Tare	6	Weigh Data	4	1	High	Medium
Container Type	3	Weigh Data	4	1	High	Medium
Scale Operator ID	15	Weigh Data	4	1	High	Medium
Date-Time Group	10	Weigh Data	4	1	High	Medium
Byte Flow 4 → 1 = 140						

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Table E-2

Operation: 2 - Bobtail in for Empty Container and Chassis

Movement: Export

Nodes Involved: 1 - Control Center; 2 - Gate; 3 - Parking Area; 7 - Empty Chassis Storage; 8 - Empty Container Storage; 11 - Hustlers/Straddle Carriers

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Carrier	25	Booking request	2	1	High	Medium
		Gate Pass	1	2	Medium	Medium
		Tractor Entry Record	2	1	High	High
Booking Number	10	Booking Request	2	1	High	High
Container Number	10	Booking Configuration	1	2	High	High
		Gate Pass	1	2	High	High
		Hustler Dispatch	1	11,8	Medium	Medium
Tractor License Number	8	Tractor Entry Record	2	1	High	High
		Gate Pass	1	2	High	High
Tractor Driver's ID	15	Tractor Entry Record	2	1	High	Medium
		Gate Pass	1	2	High	Medium
Terminal Area	3	Tractor Entry Record	2	1	High	High
		Gate Pass	1	2	High	High
		Hustler Dispatch	1	14,7	High	Low
		Hustler Dispatch	1	11,3	High	Low
Chassis Number	10	Status Change	1	11,7	High	Low
		Status Change	11	1,7	High	Low
Chassis Storage Location	5	Status Change	11	1,7	Medium	Medium
		Hustler Dispatch	1	14,8	High	High
Empty Container Storage Location	5	Hustler Dispatch	1	11,8	High	High
			1	11,7	High	High
		Status Change, Hustler Dispatch	1	11,8	High	High
Date-Time Group	10	Gate Pass Format	1	2	Medium	Medium
		Status Change	11	1,7	Medium	High
		Tractor Position	3	1	Medium	Medium
		Tractor Position	3	1	Medium	Medium
		Status Change	11	1,3	Medium	Medium

Byte Flow

1→2 = 81	3→1 = 20	11→3 = 10	1→8 = 5
1→11 = 41	11→7 = 35	1→7 = 38	
2→1 = 86	11→1 = 35	1→3 = 13	

Table E-3

Operation: 3 - Rail Car Unloading

Movement: Export

Nodes Involved: 1 - Control Center; 5 - TOFC/COFC Ramp;
7 - Empty Chassis Storage;
10 - Transtainers
11 - Hustlers/Straddle Carriers

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Chassis Storage Location	5	Hustler Dispatch	1	11,7	Medium	Medium
		Status Change	11	1,7	Medium	Medium
Chassis Number	10	Status Change	11	1,8	Medium	Medium
Terminal Area	3	Hustler Dispatch	1	11,5	Medium	Medium
		Hustler Dispatch	1	10,5	Medium	Medium
Container Number	10	Status Change	11	1	Medium	High
		Status Change	5	1	Medium	High
Yard Equipment Serial No.	5	Status Change	5	1	Medium	High
Date-Time Group	10	Status Change	11	1,7	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	5	1	Medium	Medium

Byte Flow

1→ 7 = 5   5→ 1 = 25
1→10 = 8   11→ 1 = 45
1→11 = 8   11→ 7 = 25

Table E-4

Operation: 4 - Full Container from Parking Area to Storage

Movement: Export

Nodes Involved: 1 - Control Center; 3 - Parking Area;
9 - Full Container Storage;
11 - Hustlers/Straddle Carriers

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Location	3	Hustler Dispatch	1	14,3,10	Medium	Medium
Container Number	9	Status Change	11	1	Medium	High
		Status Change	3	1	Medium	High
		Status Change	9	1	Medium	High
Chassis Number	9	Status Change	11	1	Medium	High
		Status Change	3	1	Medium	High
		Status Change	9	1	Medium	High
Container Storage Location	5	Status Change	9	1	Medium	Medium
Chassis Storage Location	5	Status Change	9	1	Medium	High
Date-Time Group	9	Status Change	11	1	Medium	Medium
Byte Flow $1 \to 3 = 3$ $3 \to 1 = 20$ $1 \to 9 = 3$ $9 \to 1 = 30$ $1 \to 11 = 3$ $11 \to 1 = 30$						

Table E-5

Operation: 5 - Gate Admittance

Nodes Involved: 1 - Control Center
2 - Gate

Movement: Export

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Tractor License Number	8	Create Gate Permit	2	1	High	High
Carrier	25	Create Gate Permit	2	1	High	Medium
Tractor Driver	15	Create Gate Permit	2	1	High	Medium
Shipline	25	Create Gate Permit	2	1	High	Medium
Chassis Number	10	Create Gate Permit	2	1	High	High
Container Number	10	Create Gate Permit	2	1	High	High
Terminal Employee ID	15	Create Gate Permit	2	1	High	High
Date-Time Group	10	Create Gate Permit	2	1	High	High
Byte Flow $2 \rightarrow 1 = 108$						

Table E-6

Operation: 6 - Interchange

Movement: Export

Nodes Involved: 1 - Control Center
6 - Interchange Station

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Shipline	25	Create Interchange	6	1	High	Medium
		Interchange Agreement	6	1	High	Medium
EIR Sequence Number	10	Interchange Agreement	6	1		
Carrier	25	Interchange Agreement	6	1	High	Medium
Origin	15	Interchange Agreement	6	1	High	Medium
Seal Number	6	Interchange Agreement	6	1	High	High
Container Number	10	Interchange Agreement	6	1,19	High	High
Chassis License Number	8	Interchange Agreement	6	1	High	High
Chassis Number	10		6	1,19	High	High
Tractor License Number	8	Interchange Agreement	6	1	High	High
Container Length	2		6	1	High	High
Container Type	5		6	1	High	High
Container Condition	150	Interchange Agreement	6	1,19	High	Medium
Chassis Condition	150		6	1,19	High	Medium
Remarks	100	Interchange Agreement	6	1	High	Low
Tractor Driver ID	15	Interchange Agreement	6	1	High	High
Terminal Employee ID	15	Interchange Agreement	6	1	High	High
Date-Time Group	10	Interchange Agreement	6	1	High	Medium

Byte Flow
$6 \rightarrow 1 = 564$
$6 \rightarrow 19 = 320$*

* Sent only if faulty condition found on inspection.

Table E-7

Operation: 7 - Dock Receipt Execution

Nodes Involved: 1 - Control Center
3 - Parking Area

Movement: Export

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Tractor License Number	8	Container/Chassis/Tractor Location	3	1	Medium	High
Container Number	10	Container/Chassis/Tractor Location	3	1	Medium	High
		Dock Receipt	3	1	Medium	High
Chassis Number	10	Container/Chassis/Tractor Location	3	1	Medium	High
Terminal Area	3		3	1	Medium	Medium
Exporter	25	Dock Receipt	3	1	Medium	High
Consignee	25	Dock Receipt	3	1	Medium	High
Document Number	10	Dock Receipt	3	1	Medium	High
Forwarder/Agent	25	Dock Receipt	3	1	Medium	High
Origin	15	Dock Receipt	3	1	Medium	Medium
Shipline	25	Dock Receipt	3	1	Medium	High
Booking Number	10	Dock Receipt	3	1	Medium	High
Voyage Number	5	Dock Receipt	3	1	Medium	High
Latest Pier Delivery Date	6	Dock Receipt	3	1	Medium	High
Terminal	25	Dock Receipt	3	1	Medium	High
Vessel	25	Dock Receipt	3	1	Medium	High
Port of Loading	25	Dock Receipt	3	1	Medium	High
Transshipment Port	25	Dock Receipt	3	1	Medium	High
Marks and Numbers	20	Dock Receipt	3	1	Medium	High
Number of Packages	2	Dock Receipt	3	1	Medium	Medium
Seal Number	6	Dock Receipt	3	1	Medium	High
Container Type	3	Dock Receipt	3	1	Medium	Medium

Continued ...

Table E-7 Continued

Operation: Nodes Involved:

Movement:

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Employee ID	15	Dock Receipt	3	1	Medium	High
Tractor Driver ID	25	Dock Receipt	3	1	Medium	High
Date-Time Group	10	Dock Receipt	3	1	Medium	Medium
<u>Byte Flow</u> 3→1 = 358						

Table E-8

Operation: 8 - Full Container from Storage to Apron

Movement: Export

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Area	3	Hustler dispatch	1	11, 9	Medium	Medium
Container Number	10	Status Change	11	1	Medium	High
		Status Change	9	1	Medium	High
		Status Change	11	1	Medium	High
Chassis Number	10	Status Change	11	1	Medium	High
		Status Change	11	1	Medium	High
Date-Time Group	10	Status Change	11	1	Medium	Medium
		Status Change	9	1	Medium	Medium
		Status Change	11	1	Medium	Medium
Byte Flow						
1 → 9 = 3						
1 → 11 = 3						
9 → 1 = 20						
11 → 1 = 60						

Table E-9

Operation: 9 - Empty Container to CFS to Full Container Storage

Movement: Export

Nodes Involved: 1 - Control Center; 7 - Empty Chassis Storage; 9 - Full Container Storage; 11 - Hustlers/Straddle Carriers; 12 - Container Freight Station (CFS)

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Area	3	Hustler Dispatch	1	11	Medium	Medium
		Hustler Dispatch	1	11	Medium	Medium
		Status Change	12	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Hustler Dispatch	1	7	Medium	Medium
Chassis Number	10	Status Change	11	1	Medium	Medium
		Status Change	7	1	Medium	High
		Status Change	9	1	Medium	High
Chassis Storage Location	5	Status Change	8	1	Medium	High
		Status Change	9	1	Medium	High
		Status Change	1	11	Medium	High
Container Number	10	Hustler Dispatch	1	12	Medium	High
		Hustler Dispatch	1	11	Medium	High
		Status Change	11	1	Medium	High
		Status Change	12	1	Medium	High
		Status Change	11	1	Medium	High
		Status Change	11	1	Medium	High
		Status Change	9	1	Medium	High
		Hustler Dispatch	1	11	Medium	High
		Hustler Dispatch	1	9	Medium	High
		Status Change	9	1	Medium	High
Date-Time Group	10	Status Change	11	1	Medium	Medium
		Status Change	12	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	9	9	Medium	Medium
		Status Change	7	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	9	1	Medium	Medium
Byte Flow 1→ 11 = 26 11→ 1 = 93 7→ 1 = 25 1→ 9 = 10 9→ 1 = 55 12→ 1 = 23						

Table E-10

Operation: 10 - Ship Loading

Movement: Export

Nodes Involved: 1 - Control

17 - Crane

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Load	17	1	Medium	High
Shipline	25	Load	17	1	Medium	Medium
Hatch Number	1	Load	17	1	Medium	Medium
Shipline Employee I.D.	15	Load	17	1	Medium	Medium
Date-Time Group	10	Load	17	1	Medium	Medium
Byte Flow 17 → 1 = 61						

Table E-11

Operation: 11 - Rail Car Loading

Movement: Import

Nodes Involved: 1 - Control Center
5 - TOFC/COFC Ramp
9 - Full Container Storage

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Area	3	Hustler Dispatch	1	11,9	Medium	Medium
		Hustler Dispatch	1	11,5	Medium	Medium
		Hustler Dispatch	1	10,5	Medium	Medium
Chassis Number	10	Status Change	11	1,7	Medium	Medium
		Status Change	9	1	Medium	Medium
Chassis Storage Location	5	Status Change	11	1,7	Medium	High
		Status Change	9	1	Medium	High
Container Number	10	Status Change	9	1	Medium	High
		Status Change	11	1	Medium	High
		Status Change	5	1	Medium	High
Date-Time Group	10	Status Change	9	1	Medium	Medium
		Status Change	11	7	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	5	1	Medium	Medium

Byte Flow

1→ 10 = 3	11→ 1 = 45
1→ 11 = 6	9→ 1 = 35
1→ 5 = 6	5→ 1 = 20
1→ 9 = 3	11→ 8 = 25

Table E-12

Operation: 12 - Full Container from Fumigation to Storage

Movement: Import

Nodes Involved: 1 - Control Center; 7 - Empty Chassis Storage; 9 - Full Container Storage; 11 - Hustlers/Straddle Carriers; 14 - Fumigation Shed

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Area	3	Hustler Dispatch	1	11,7	Medium	Medium
		Hustler Dispatch	1	11,14	Medium	Medium
		Container Status Change	14	1	Medium	Medium
		Hustler Status Change	11	1	Medium	Medium
Chassis Number	10	Hustler Status Change	11	1	Medium	High
		Chassis Status Change	7	1	Medium	High
		Chassis Status Change	9	1	Medium	High
Container Storage Location	5	Chassis Status Change	7	1	Medium	High
		Container/Chassis Status Change	9	1	Medium	High
Container Number	10	Hustler Status Change	11	1	Medium	High
		Container Status Change	14	1	Medium	High
		Hustler Dispatch	1	11,9	Medium	High
		Container/Chassis Status Change	9	1	Medium	High
Date-Time Group	10	Hustler Status Change	11	1	Medium	Medium
		Chassis Status Change	7	1	Medium	Medium
		Hustler Status Change	11	1	Medium	Medium
		Container Status Change	14	1	Medium	Medium
		Hustler Status Change	11	1	Medium	Medium
		Status Change	9	1	Medium	Medium
Byte Flow 1→ 7 = 3 7→ 1 = 25 1→ 9 = 10 9→ 1 = 35 1→11 = 13 11→ 1 = 53 1→14 = 3 14→ 1 = 23						

Table E-13

Operation: 13 - Full Container from Storage to Fumigation

Movement: Import

Nodes Involved: 9 - Full Container Storage
11 - Hustlers/Straddle Carriers
14 - Fumigation Shed

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Hustler dispatch	1	11, 9	Medium	High
	11	Status Change	11	1	Medium	High
		Status Change	9	1	Medium	High
		Status Change	11	1	Medium	High
Container Storage Location	5	Hustler Dispatch	1	11, 9	Medium	Medium
Chassis Number	10	Status Change	9	1	Medium	High
		Status Change	11	1	Medium	High
Terminal Area	3	Hustler Dispatch	1	11, 14	Medium	Medium
		Status Change	14	1	Medium	Medium
Date-Time Change	10	Status Change	9	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	14	1	Medium	Medium

Byte Flow

$1 \rightarrow 9 = 15$
$1 \rightarrow 11 = 18$
$1 \rightarrow 14 = 3$
$9 \rightarrow 1 = 30$
$11 \rightarrow 1 = 20$
$14 \rightarrow 1 = 13$

Table E-14

Operation: 14 - Full Container from Storage to Customs

Movement: Import

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
13 - Customs/USDA

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Hustler Dispatch	1	11, 9	Medium	High
		Status Change	11	1	Medium	High
		Status Change	9	1	Medium	High
		Status Change	11	1	Medium	High
Container Storage Location	5	Hustler Dispatch	1	11, 9	Medium	Medium
		Status Change	9	1	Medium	Medium
Chassis Number	10	Status Change	9	1	Medium	High
		Status Change	11	1	Medium	High
Terminal Area	3	Hustler Dispatch	1	11, 13	Medium	Medium
		Status Change	13	1	Medium	Medium
Date-Time Change	10	Status Change	13	1	Medium	Medium
		Status Change	9	1	Medium	Medium
		Status Change	11	1	Medium	Medium
Byte Flow 1 → 9 = 15 1 →11 = 18 1 →13 = 3 9 → 1 = 35 11 →1 = 30 13 →1 = 3						

Table E-15

Operation: 15 - Full Container from Customs to Storage

Nodes Involved: 1 - Control Center
7 - Empty Chassis Storage
9 - Full Container Storage

Movement: Import

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Area	3	Hustler Dispatch	1	11,7	Medium	Medium
		Hustler Dispatch	1	11,13	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	13	1	Medium	Medium
Chassis Number	10	Status Change	11	1	Medium	High
		Status Change	7	1	Medium	High
		Status Change	9	1	Medium	High
Storage Location	5	Status Change	9	1	Medium	High
Container Number	10	Hustler Dispatch	1	11,13	Medium	High
		Status Change	11	1	Medium	High
		Status Change	13	1	Medium	High
		Hustler Dispatch	1	11,9	Medium	High
		Status Change	9	1	Medium	High
Seal Number	6	Status Change	13	1	Medium	High
Date-Time Group	10	Status Change	7	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	9	1	Medium	Medium
		Status Change	13	1	Medium	Medium
Byte Flow 1→ 7 = 3 9→ 1 = 25 1→13 = 13 11→ 1 = 43 1→11 = 26 13→ 1 = 29 7→ 1 = 20						

Table E-16

Operation: 16 - Full Container from Storage to CFS for Stripping

Movement: Import

Nodes Involved:
1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
12 - Container Freight Station (CFS)

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Hustler Dispatch	1	11,9	Medium	High
		Status Change	11	1,12	Medium	High
		Status Change	9	1	Medium	High
Container Storage Location	5	Hustler Dispatch	1	11,9	Medium	Medium
		Status Change	9	1	Medium	Medium
Chassis Number	10	Status Change	9	1	Medium	High
		Status Change	11	1,12	Medium	High
Terminal Area	3	Hustler Dispatch	1	11,12	Medium	Medium
		Status Change	12	1	Medium	Medium
Date-Time Group	10	Status Change	11	1,12	Medium	Medium
		Status Change	9	1	Medium	Medium
		Status Change	14	1	Medium	Medium
		Status Change	12	1	Medium	Medium
Byte Flow 1→ 9 = 15 9→ 1 = 35 1→11 = 18 11→ 1 = 40 1→12 = 13 12→ 1 = 13						

Table E-17

Operation: 17 - Empty Container from CFS to Empty Container Storage

Movement: Import

Nodes Involved: 1 - Control Center
8 - Empty Container Storage
11 - Hustlers/Straddle Carriers
12 - Container Freight Station (CFS)

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Area	3	Status Change	12	1	Medium	Medium
		Hustler Dispatch	1	11, 12	Medium	Medium
		Hustler Dispatch	1	11, 8	Medium	Medium
		Status Change	12	1	Medium	Medium
Container Number	10	Status Change	12	1	Medium	High
		Status Change	11	1	Medium	High
		Status Change	12	1	Medium	High
		Status Change	8	1	Medium	High
Chassis Number	10	Status Change	11	1	Medium	High
		Status Change	12	1	Medium	High
Container Storage Location	5	Status Change	8	1	Medium	High
Date-Time Change	10	Status Change	12	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	12	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	8	1	Medium	Medium
Byte Flow 1 → 8 = 3 1 → 11 = 6 1 → 12 = 3 ——— 8 → 1 = 25 11 → 1 = 40 12 → 12 = 56						

Table E-18

Operation: 18 - Ship Discharge

Movement: Import

Nodes Involved: 1 - Control Center
16 - Apron

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Vessel	20	Sequence List	16	1	High	High
Shipline	25	Sequence List	16	1	High	Medium
Seal Number	6	Sequence List	16	1	High	High
Container Number	10	Sequence List	16	1	High	High
Container Length	2	Sequence List	16	1	High	Medium
Container Type	3	Sequence List	16	1	High	Medium
Container Height	4	Sequence List	16	1	High	Medium
Chassis Number	10	Sequence List	16	1	High	Medium
Terminal Employee I.D.	15	Sequence List	16	1	High	Medium
Date-Time Change	10	Sequence List	16	1	High	Medium

<u>Byte Flow</u>

16 $\rightarrow$ 1 = 95

Table E-19

Operation: 19 - Container from Apron to Storage

Movement: Import

Nodes Involved: 1 - Control Center
9 - Full Container Storage
11 - Hustlers/Straddle Carriers
16 - Apron

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Hustler Dispatch	1	11, 9	Medium	High
		Status Change	11	1	Medium	High
		Status Change	11	1	Medium	High
		Status Change	9	1	Medium	High
Storage Location	5	Hustler Dispatch	1	11, 9	Medium	Medium
		Status Change	9	1	Medium	Medium
Container Chassis Number	10	Status Change	11	1	Medium	High
		Status Change	9	1	Medium	High
Date-Time Change	10	Status Change	11	1	Medium	Medium
		Status Change	11	1	Medium	Medium
		Status Change	9	1	Medium	Medium

Byte Flow

$1 \rightarrow 11 = 15$
$1 \rightarrow 9 = 15$
$9 \rightarrow 1 = 35$
$11 \rightarrow 1 = 50$

Table E-20

Operation: 20 - Bobtail in for Full Container and Chassis

Movement: Import

Nodes Involved: 1 - Control Center; 2 - Gate; 3 - Parking Area; 9 - Full Container Storage; 11 - Hustlers/Straddle Carriers

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Carrier	25	Delivery Order	2	1	High	High
		Gate Pass	1	2	High	High
		Container Pass	2	1	High	High
Delivery Order No.	10	Delivery Order	2	1	High	High
		Container Pass	1	2	High	High
Container No.	10	Delivery Order	2	1	High	High
		Gate Pass	1	2	High	High
		Container Pass	1	2	High	High
		Status Change	1	11	High	High
		Status Change	1	9	Medium	High
		Status Change	11	1	Medium	High
		Status Change	3	1	Medium	High
		Status Change	3	1	Medium	High
		Status Change	3	1	Medium	High
Ship Line	25	Delivery Order	2	1	High	Medium
		Container Pass	1	2	High	Medium
Consignee	25	Delivery Order	2	1	High	High
		Container Pass	1	2	High	High
Tractor License No.	8	Tractor Location	[illegible]	1	High	High
		Gate Pass	[illegible]	2	High	High
		Tractor Location	[illegible]	1	High	High
		Tractor Location	3	1	High	High
Tractor Driver's ID	15	Tractor Location	2	1	High	High
		Gate Pass	1	2	High	High
		Tractor Location	3	1	High	High
Terminal Area	3	Tractor Location	2	1	High	Medium
		Gate Pass	1	2	High	Medium
		Status Change	11	1	High	Medium
		Tractor Location	3	1	High	Medium
		Tractor Location	3	1	High	Medium
Storage Location	5	Container Pass	1	2	High	High

Continued ...

Table E-20 Continued

Operation:

Nodes Involved:

Movement:

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
		Hustler Dispatch	1	11,9	Medium	High
		Status Change	9	1	Medium	High
		Status Change	3	1	Medium	High
		Status Change	3	1	Medium	High
Seal Number	6	Container Pass	1	2	High	High
Chassis Number	10	Container Pass	1	2	High	High
		Hustler Dispatch	1	11,9	High	High
		Status Change	11	1	High	High
		Status Change	9	1	High	High
		Status Change	3	1	High	High
		Status Change	3	1	High	High
		Status Change	3	1	High	High
Terminal Employee ID	25	Container Pass	1	2	High	High
Booking Number	10	Container Pass	1	2	High	High
Container Height	4	Container Pass	1	2	High	High
Container Length	2	Container Pass	1	2	High	High
Container Type	3	Container Pass	1	2	High	High
No. of Times Container Moved	2	Container Pass	1	2	High	High
Customs Status	1	Container Pass	1	2	High	High
Cargo Weight	6	Container Pass	1	2	High	High
Cargo Description	200	Container Pass	1	2	High	High
Vessel	20	Container Pass	1	2	High	High
Voyage Number	5	Container Pass	1	2	High	High
Broker Reference Number	6	Container Pass	1	2	High	High
Shipper	25	Container Pass	1	2	High	High
Shipper's Address	50	Container Pass	1	2	High	High

Continued ...

Table E-20 Continued

Operation: Nodes Involved:

Movement:

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Consignee's Address	50	Container Pass	1	2	High	High
Container Tare	6	Container Pass	1	2	High	High
Hazard Code	2	Container Pass	1	2	High	High
Direction (Import,Export)	1	Container Pass	1	2	High	High
Type Shipment (HH,HP,etc.)	1	Container Pass	1	2	High	High
Date-Time Group	10	Delivery Order	2	1	High	High
		Container Pass	1	2	High	High
		Gate Pass	1	2	High	High
		Container Pass (5 times)	1	2	High	High
		Status Change	11	1	High	High
		Status Change	9	1	High	High
		Status Change	3	1	H gh	High
		Status Change	3	1	High	High
<u>Byte Flow</u> 1→ 2 = 566 3→ 1 = 119 1→ 9 = 25 9→ 1 = 25 1→11 = 25 11→ 1 = 36 2→ 1 = 156						

Table E-21

Operation: 21 - Interchange of Import Container and Chassis   Nodes Involved: 1 - Control Center
6 - Interchange Station

Movement: Import

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Interchange Agreement (IA)	6	1	High	High
		Maintenance Required	6	15	Medium	High
EIR Sequence Number	10	Interchange Agreement	6	1	Medium	High
Shipline	25	Interchange Agreement	6	1	Medium	Medium
Chassis Number	10	Maintenance Required	6	1	Medium	High
		Maintenance Required	6	15	Medium	High
Chassis License Number	8	Interchange Agreement	6	1	Medium	High
Seal Number	6	Interchange Agreement	6	1	Medium	High
Tractor License Number	8	Interchange Agreement	6	1	Medium	High
Tractor Driver ID	15	Interchange Agreement	6	1	Medium	High
Carrier (Truckline)	25	Interchange Agreement	6	1	Medium	High
Container Tare	6	Interchange Agreement	6	1	Medium	High
Container Type	3	Interchange Agreement	6	1	Medium	High
Container Length	2	Interchange Agreement	6	1	Medium	High
Container Gross Weight	6	Interchange Agreement	6	1	Medium	High
Container Owner/Lessee	25	Interchange Agreement	6	1	Medium	High
Container Height	2	Interchange Agreement	6	1	Medium	High
Container Condition	150	Maintenance Required	6	1	Medium	High
		Maintenance Required	6	15	Medium	Medium
Chassis Tare	6	Interchange Agreement	6	1	Medium	Medium
Chassis Type	3		6	1	Medium	Medium
Chassis Length	2	Interchange Agreement	6	1	High	Medium
Chassis Owner/Lessee	25	Interchange Agreement	6	1	High	High
Chassis Condition	150	Interchange Agreement	6	1	High	Medium
		Maintenance Required	6	15	Medium	Medium
					Continued	...

Table E-21 Continued

Operation:

Nodes Involved:

Movement:

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Terminal Employee ID	15	Interchange Agreement	6	1	Medium	Medium
Date-Time Group	10	Interchange Agreement	6	1	High	High
Byte Flow 6→ 1 = 522 6→ 15 = 340						

Table E-22

Operation: 22 - Container Tagged for Customs Inspection

Nodes Involved: 1 - Control Center
13 - Customs/USDA

Movement: Import

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Customs Status	13	1	Low	High
Customs Status	1	Customs Status	13	1	Low	High
Date-Time Change	10	Customs Status	13	1	Low High	
Byte Flow 13 → 1 = 21						

Table E-23

Operation: 23 - Release of Container by Customs

Nodes Involved: 1 - Control Center
13 - Customs/USDA

Movement: Import

Data Element Name	Length (Bytes)	Message	Sending Node	Receiving Node	Priority	Accuracy
Container Number	10	Customs Status	13	1	Medium	High
Customs Status	1	Customs Status	13	1	Medium	High
Seal Number	6	Customs Status	13	1	Medium	High
Date-Time Change	10	Customs Status	13	1	Medium	High
Byte Flow 13 → 1 = 88						

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
1341-01-1-1813

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
Automated Management Control System For Public Marine Terminals Phase I: System Definition, System Analysis, and Concept Design

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